

A National Strategic Geospatial Information Framework to
Support the Implementation of the Sustainable
Development Goals (SDGs)

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This dissertation is dedicated to Marina.

Abstract

The 2030 Agenda for Sustainable Development, anchored by 17 Sustainable Development Goals (SDGs), 169 targets, and a global indicator framework, provides a transformative and integrated approach to sustainable development. Although not readily apparent, the SDGs are highly dependent on geospatial information and enabling technologies as the primary data and tools for relating people to their location, place and environment, and to measure ‘where’ progress is, or is not, being made, particularly at sub-national and local levels. For this reason, the 2030 Agenda specifically references the need to exploit geospatial information and other data sources to ensure that high-quality, timely and reliable data, disaggregated by geographic location and other characteristics, is available – especially to developing countries.

However, in the pursuit for sustainable development, many countries continue to face a series of impediments that exacerbate their ability and ‘opportunity’ to participate fully in the implementation of the SDGs, to support national development, economic prosperity, and, through that, a global and thriving information economy. These include institutional challenges in data production: having the required human capital and skillsets; effective and sustained access to digital technology, the Internet and the corresponding computer literacy; to the provision and exploitation of new data needs, information systems, analytics, and associated enabling tools and technologies to support the timely and reliable implementation of the SDGs. They also include policy challenges, including strategic leadership, understanding and awareness of national geospatial information policy, frameworks, and associated implementation roadmaps.

Governments are failing in their attempts to address the geospatial needs of the SDGs, as they lack the required guidance to assist them. National data systems are often fragmented, and with no integrative strategic frameworks, roadmaps, and tools in place to determine how geospatial information can be implemented and integrated into the SDGs. These problems are a very real impediment for many developing countries, those most affected by the challenges and need to achieve national development, to being able to fully realise the implementation of the SDGs – and to ensure no one is left behind.

As a tangible means to support the implementation of the SDGs, this research investigates the key aspects and impediments as to why geospatial information remains unable to adequately contribute its data, systems, and integrative capabilities to support the measuring, monitoring, and implementation of the SDGs, particularly at a national level. The research addresses this problem through its overall aim; to define, develop, test, and apply a new national strategic geospatial information framework to enable countries to integrate geospatial information into national sustainable development strategies and processes, with particular application to the SDGs. Through

the implementation of the strategic framework, countries will be able to measure and monitor progress and transformative change within their national circumstances, and mainstream evidence-based policy-setting and decision-making to achieve sustainable development.

To achieve the research aim, a mixed methods research design is employed through the application of archival research and a two-dimensional case study. Archival research is used to: examine and investigate existing concepts on sustainable development theory and practice, and review the relationships with and role of geospatial information; and evaluate the evolution and development of geospatial information, its uptake at the intergovernmental level, applicability to the SDGs, and identify issues and challenges impeding geospatial information from contributing more to sustainable development.

Given the emphasis on the SDGs and developing countries, a precursor to the development of the strategic framework was to first review the relevance of the digital divide and the related data availability and integration issues for the SDGs. Therefore, the research introduces and develops the components of the ‘geospatial digital divide’ and the complex challenges that continue to exacerbate the ability for many developing countries to bridge this divide. The research then develops a conceptual integrated geospatial information systems framework as an integrative sustainable development ‘data flow’ to provide the building blocks and processes for countries to measure and monitor the SDGs with relevant and timely location-based data.

A two-dimensional case study approach, focusing on developing countries, is then undertaken – regionally within the continent of Africa, and nationally within the country of Ethiopia. The first part of the case study iteratively defines, develops, and tests the prototype strategic framework with experts in African countries. The second part of the case study implements and applies the strategic framework in Ethiopia, through the Ethiopian Geospatial Information Institute.

During the course of this research, the legitimacy of the strategic framework was recognised by the United Nations and World Bank as a means to progress an overarching geospatial framework to assist developing countries to bridge the geospatial digital divide. In August 2018, the strategic framework was adopted by UN-GGIM as the Integrated Geospatial Information Framework (IGIF). The outcome of the framework’s adoption by UN-GGIM immediately validated its critical need.

The research findings confirmed the need for an overarching strategic framework that could be general enough to address many systemic institutional barriers through aspirational principles and goals, while also being detailed enough to provide the pragmatic pathways and roadmap to overcome the research problem. The IGIF now provides that framework. While linking to, and building upon NSDIs, the strength of the IGIF is that it is not a data infrastructure. It is an integrated framework and a knowledge infrastructure that can be applied to all countries and all situations and circumstances.

Declaration

This is to certify that:

- i. the dissertation comprises only my original work towards the degree of Doctor of Philosophy;
- ii. due acknowledgement has been made in the text to all other material used;
- iii. parts of this work have been published in refereed journals or refereed conference proceedings as listed in the Preface; and
- iv. the dissertation is less than 100,000 words in length, exclusive of tables, maps, bibliographies and appendices.

Greg Scott
New York, May 2020

Preface

The following is a list of published works that has been produced as part of this thesis:

Scott, G. & Rajabifard, A. 2015, Integrating Geospatial Information into the 2030 Agenda for Sustainable Development, *Twentieth United Nations Regional Cartographic Conference for Asia and the Pacific Jeju*, 6 - 9 October 2015, United Nations, New York.

Scott, G. & Rajabifard, A. 2017, Sustainable development and geospatial information: a strategic framework for integrating a global policy agenda into national geospatial capabilities, *Geo-spatial Information Science*, vol. 20, no. 2, pp. 59-76.

Scott, G. & Rajabifard, A. 2019, SDGs Roadmap, *Sustainable Development Goals Connectivity Dilemma: Land and Geospatial Information for Urban and Rural Resilience*, pp. 13-44, CRC Press, Taylor and Francis Group.

Scott, G. 2018, The Role of Geospatial Information and Earth Observations in the SDGs: A Policy Perspective, *CEOS Handbook: Satellite and Earth Observations in Support of the Sustainable Development Goals, Special 2018 Edition*, pp. 36-39, European Space Agency.

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It seems that family are always thanked last, although they are the most important. For every evening and weekend spent on the computer and researching, was yet another evening and weekend lost to my family. That was a sacrifice they were willing to accept, but one that, to this day, I found difficult. Nonetheless, we got there!!! To the kids, thanks for hanging in there. Rachael, thanks for your assistance in bringing the structure of the dissertation together. To my wife Marina, a heartfelt thank you for being there and pushing me those many times when I was ready to give up. This dissertation is for you and because of you. With all my love.

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List of acronyms

AI	Artificial Intelligence
APS	Australian Public Service
ARC/INFO	ESRI's first GIS coverage file format
CALFORM	Choropleth Mapping
CGIS	Canada Geographic Information System
CGRI	Countries Geospatial Readiness Index
COBIT	Control Objectives for Information and Related Technologies
CODI	Committee on Development Information
CODIST	Committee on Development Information, Science and Technology
CoE4UNSDI	Centre of Excellence for the United Nations Spatial Data Infrastructure
COP21/CMP11	21st Session of the Conference of the Parties / 11 th Session of the Meeting of the Parties
DEMs	Digital Elevation Models
DIKW	Data-Information-Knowledge-Wisdom
ECOSOC	United Nations Economic and Social Council
ECU	Experimental Cartography Unit
EG-ISGI	United Nations Expert Group on the Integration of Statistical and Geospatial Information
EGII	Ethiopian Geospatial Information Institute
ENSDI	Ethiopian National Spatial Data Infrastructure
ESRI	Environmental Systems Research Institute
FGDC	Federal Geographic Data Committee
GEO	Group on Earth Observations
GIS	Geographic Information System
GPS	Global Positioning System
GRID	ESRI raster GIS file format
GSDI	Global Spatial Data Infrastructure Association
GSGF	Global Statistical Geospatial Framework
IAEG-SDGs	Inter-agency Expert Group on Sustainable Development Goal Indicators
ICSM	Intergovernmental Committee for Surveying and Mapping
ICT	Information and Communication Technologies
ICT4D	Information and Communication Technologies for Development

IDRISI	GIS tool set developed by Clark University
IEAG	Independent Expert Advisory Group on a Data Revolution for Sustainable Development
IGIF	United Nations Integrated Geospatial Information Framework
INSPIRE	Infrastructure for Spatial Information in the European Community
IoT	Internet of Things
LDCs	Least Developed Countries
LiDAR	Light Detection and Ranging
MDGs	Millennium Development Goals
NERC	Natural Environment Research Council
NSDI	National Spatial Data Infrastructure
NSS	National Statistical-Spatial Framework
ODYSSEY	Extension of POLYVRT with more efficient polygon overlay algorithm and vector-based GIS system
OECD	Organisation for Economic Cooperation and Development
OMB	United States Office of Management and Budget
OSM	OpenStreetMap
OWG	Open Working Group on Sustainable Development Goals of the General Assembly
PC-IDEA	Permanent Committee for the Infrastructure of Geospatial Data of the Americas
PCGIAP	United Nations Permanent Committee on GIS Infrastructure for Asia and the Pacific
PMSEIC	Prime Minister's Science and Engineering Innovation Council
POLYVRT	Data conversion and analysis to topologically structure data
RCMRD	Regional Centre for Mapping of Resources for Development
SAMOA	SIDS Accelerated Modalities of Action Pathway
SATs	SDGs and Agenda 2063 Targets
SDGs	Sustainable Development Goals
SDI	Spatial Data Infrastructure
SDOs	Standards Development Organisations
SIDS	Small Island Developing States
SPOT	Satellites Pour l'Observation de la Terre
STI	Science, Technology and Innovation
SYMAP	Synergraphic Mapping for computer generated maps
SYMVU	3D perspective views of SYMAP

TCP/IP	Transmission Control Protocol and Internet Protocol
TIGER	Topologically Integrated Geographic Encoding and Referencing
TM	Thematic Mapper
UN	United Nations
UN-GGIM	United Nations Committee of Experts on Global Geospatial Information Management
UN-GGIM-AP	United Nations Committee of Experts on Global Geospatial Information Management for Asia and the Pacific
UN-GGIM: Americas	United Nations Committee of Experts on Global Geospatial Information Management for the Americas
UN-GGIM: Arab States	United Nations Committee of Experts on Global Geospatial Information Management for the Arab States
UN-GGIM: Europe	United Nations Committee of Experts on Global Geospatial Information Management for Europe
UNCHE	United Nations Conference on the Human Environment
UNCSD	United Nations Conference on Sustainable Development
UNECA	United Nations Economic Commission for Africa
UNECD	United Nations Conference on Environment and Development
UNECE	United Nations Economic Commission for Europe
UNEP	United Nations Environment Programme
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific
UNGIWG	United Nations Geographic Information Working Group
UNGN	United Nations Geospatial Network
UNRCC	United Nations Regional Cartographic Conference
UNRCC-A	United Nations Regional Cartographic Conference for the Americas
UNRCC-AP	United Nations Regional Cartographic Conference for Asia and the Pacific
UNSC	United Nations Statistical Commission
UNSD	United Nations Statistics Division
UNSDI	United Nations Spatial Data Infrastructure
VGI	Volunteered Geographic Information
VOI	Value of Information
WCED	United Nations World Commission on Environment and Development
WSSD	United Nations World Summit on Sustainable Development

Chapter 1 – Introduction

1.1 Research Background

Geospatial information, enabling technologies, and geographic location are powerful enablers for all countries to systematically measure and monitor sustainable development. However, very little is understood regarding the role of geography in sustainable development processes at the national and intergovernmental level, including how geospatial information can be applied to sustainable development, and how national strategic frameworks can be implemented to bring the two together in a coherent and integrated manner (Scott and Rajabifard, 2017).

The origin and evolution of sustainable development has a long history in the literatures of both development and environmentalism since the early 1960s. However, its first acceptance as a viable concept was signalled in 1987, with the adoption of the landmark report *Our Common Future* (WCED, 1987) by the United Nations General Assembly (General Assembly). *Our Common Future* introduced and captured what is now the classic definition of sustainable development: ***“development which meets the needs of the present without compromising the ability of future generations to meet their own needs”*** (WCED, 1987, p. 43). Since its inception, sustainable development has continued to advance, but has evolved to mean different things to different people, and in some cases all things to all people; hence it is a term that is as misunderstood as much as it is understood (Hopwood et al., 2005; Adams, 2009; Shao, Li and Tang, 2011).

Despite this ambiguity and being open to interpretation in its definition and ability to be measured, sustainable development is now being embraced more than ever by global leaders as the world comes to terms with urgent and emerging development challenges. This was confirmed by the General Assembly in September 2015 when world leaders adopted *Transforming our World: The 2030 Agenda for Sustainable Development* (United Nations, 2015a). The 2030 Agenda for Sustainable Development is the agreed global and united policy to guide the way countries collectively manage and transform the social, economic and environmental dimensions of people and the planet through to at least 2030. As a blueprint for action, the 2030 Agenda is intentionally ambitious, providing a transformative and integrated approach to sustainable development; and anchored by a set of 17 integrated Sustainable Development Goals (SDGs), 169 targets, and a global indicator framework, in order to measure and monitor progress (United Nations, 2015a).

With considerable emphasis on countries being able to measure and monitor progress, the broad and transformative nature of the 2030 Agenda has ushered in a ‘new era’ in thinking about sustainable development (United Nations, 2015a). Unlike its predecessor, the Millennium Development Goals (MDGs), the 2030 Agenda presents countries and the global development community with a set of significant monitoring and reporting metrics that are almost entirely geographic in nature. This requires new and innovative data sources and data integration approaches to address the world’s development challenges and to ‘leave no one behind’ (Scott, 2018).

To meet this challenge, the 2030 Agenda articulates specific references for the need of high quality, timely, reliable and disaggregated data, including Earth observations and geospatial information, in the area of follow up and review, but the application of this data is not qualified: *“We will support developing countries, particularly African countries, LDCs, SIDS and LLDCs¹, in strengthening the capacity of national statistical offices and data systems to ensure access to high quality, timely, reliable and disaggregated data. We will promote transparent and accountable scaling-up of appropriate public-private cooperation to exploit the contribution to be made by a wide range of data, including earth observation and geospatial information, while ensuring national ownership in supporting and tracking progress”* (United Nations, 2015a, p. 32). These data needs are elaborated through an associated goal, target and date. For instance Goal 17: Partnerships for the goals, in the area of data, monitoring and accountability states: *“By 2020, enhance capacity-building support to developing countries, including for least developed countries and small island developing States, to increase significantly the availability of high-quality, timely and reliable data disaggregated by income, gender, age, race, ethnicity, migratory status, disability, geographic location and other characteristics relevant in national contexts”* (United Nations, 2015a, p. 27). What is not articulated is how the availability of high-quality, timely and reliable data will be realised by 2020 or be applied and integrated into national, regional, or global development approaches.

On 1 January 2016, the world officially began implementation of the 2030 Agenda, and some four years later the clock is ticking. The Agenda’s objective is to transform the social, economic and environmental dimensions of people and the planet, particularly in the developing world, to eliminate extreme poverty, to create a future for our children and their children, and to leave no one behind (United Nations, 2015a). But what remains to be understood is the scale and dimensions of the world’s development problems, where they are, whom they impact, what are the causes, and how they can be remedied (Scott, 2018)?

In the pursuit for sustainable development, many countries continue to face a series of impediments that exacerbate their ability and ‘opportunity’ to participate fully in the implementation of the 2030 Agenda, to support national development, social and economic prosperity, and through that, a global and thriving information economy (Scott and Rajabifard, 2019). What is not known, are the data needs to measure progress; where is that data and what are the strategic data frameworks, methods and policies to enable its access and realisation? To be able to measure and monitor development progress for those most in need (the most vulnerable countries) requires transformative change, not only in delivering on such a broad and ambitious Agenda, but also in how and what data, *high quality, timely, reliable and disaggregated data*, is brought into effect to overcome significant social, economic and environmental challenges that are almost entirely geographic in nature.

¹ Least Developed Countries, Small Island Developing States, and Land Locked Developing Countries.

The adoption of the 2030 Agenda has provided the global policy mandate for all countries to exploit the contribution to be made by geospatial information as a key ‘means of implementation’ to support the SDGs, targets and global indicators. However, it is not readily apparent if this provides enough enabling momentum and ‘visibility’ for countries to actually implement change and achieve the mandate for geospatial information to be mainstreamed into sustainable development. This is because the enabling national mechanisms and frameworks to facilitate a positive outcome, particularly at the national policy level, are not readily available, do not exist, or it is simply that what is required is not understood.

While the origins and evolution of sustainable development, including its influence in global development, has historically been contentious, its undeniable need and role at an intergovernmental level is now acknowledged and understood by world leaders (Adams 2009). Conversely, very little is understood regarding the role of geography in sustainable development processes at the national and intergovernmental level, including how geospatial information can be applied to sustainable development, and how national strategic frameworks can be implemented to bring the two together in a coherent and integrated manner.

1.2 Research Formulation

1.2.1 Defining the research problem

Although not readily apparent, the SDGs are highly dependent on geospatial information and enabling technologies as the primary data and tools for relating people to their location, place and environment, and to measure ‘where’ progress is, or is not, being made, particularly at sub-national and local levels (UN-GGIM, 2019a). This is why the 2030 Agenda explicitly supports the need to exploit geospatial information and other data sources to ensure that high-quality, timely and reliable data disaggregated by geographic location and other characteristics is available – especially to developing countries.

However, even with much advocacy and many global dialogues, the recognition of the critical importance of geospatial information in sustainable development processes has been, and sadly remains, limited. Regardless of logical synergies and linkages over a long period of time the reality is that even today, in a highly data rich and technology driven global environment, there has been very little connection and fusion between sustainable development and geography, geospatial information and related enabling architectures such as National Spatial Data Infrastructures (NSDIs) at either the political or the administrative level (Pesch, 2014).

Although world leaders have decided how sustainable development will be addressed in the implementation of the 2030 Agenda, and real baseline data is now needed to measure and monitor progress, there has been little understanding of the how geospatial information will support the implementation of the SDGs. But there is a bigger problem – one of know-how and capacity.

In the second annual report on progress towards the Sustainable Development Goals, provided to the United Nations High-Level Political Forum in July 2017, the Secretary-General of the United Nations observed that although implementation of the 2030 Agenda has begun, the rate of progress in many areas is far slower than needed to meet the targets by 2030. He underscored the need for reliable, timely, accessible and disaggregated data to measure progress, inform decision-making and ensure that everyone is counted; and the technology and skills necessary to collect and integrate data from multiple sources, including the integration of geospatial information with statistics and other data. (United Nations, 2017a).

Put simply, there are a number of interconnected problems that become more complex and compounded as they transition from developed, to developing, to the least developed countries (LDCs):

1. Governments are failing in being able to address the needs of the SDGs as they lack the required guidance to assist them – frameworks, approaches and methodologies;
2. While many countries, especially those that contributed to the MDGs, understand nationally aggregated statistical and population development data, they are not able to respond to the many development problems with ‘geographic location’ because they do not know how;
3. National data systems that do exist are fragmented; there are no strategic integrative frameworks and tools in place to manage and overcome these ongoing realities;
4. There are presently no evident national strategic frameworks, roadmaps or federated geospatial infrastructure for governments to determine how geospatial information can be implemented and integrated into the SDGs, especially at local and national levels; and
5. These problems are a very real impediment for many developing countries, those most affected by the challenges and need to achieve national development, being able to fully realise the implementation of the SDGs – and to ensure no one is left behind.

These issues raise several questions. Why has geospatial information not been visible as an integrative and coherent capability in the global development agenda? What are the impediments? How can geospatial information be implemented and integrated, at a national and decision-making level, in order to contribute holistically – to the whole rather than just some parts - to measuring and monitoring the targets and indicators of the SDGs? Further, can a strategic framework be developed in order for countries to determine how geospatial information can be integrated into national development agendas, strategic priorities, and the key areas of interest and national circumstances for government?

In response to these issues, the following research problem statement has been developed:

Research Problem

Despite the demonstrated demand and urgent global development needs, the problem is that geospatial information and enabling technologies remain unable to adequately contribute their data, systems and integrative capabilities to support the measuring, monitoring and implementation of the SDGs and targets of the 2030 Agenda for Sustainable Development, particularly at a national level.

1.2.2 Research aim and objectives

This research explores the key aspects and impediments as to why geospatial information is not more prominent and integrated into national sustainable development processes, and provides a conceptual integrative framework that can be used as a tool to solve the problem, improve understanding, address sustainable development data gaps, and assist developing countries in overcoming the digital and technological divide that exists between the developed and developing world. Given the broad nature of these impediments and given that this research aims to develop and implement an integrative geospatial framework applicable for all countries, it is important to recognise that this research is applied research, which is descriptive and deductive and results in a solution to the problem.

Articulating the above research problem leads to a research aim, which is to:

Research Aim

Define, develop, test and apply a new national strategic geospatial information framework to enable countries to integrate geospatial information into national sustainable development strategies and processes, with particular application to the SDGs, so that they will be better able to measure and monitor progress and transformative change within their individual national circumstances, and mainstream evidence-based policy-setting and decision-making to achieve sustainable development.

Given the breadth and local to global dimensions and reach of the research problem and aim, and in considering the research questions, the following research objectives have been formulated:

Research Objectives	Chapter/Approach
1. Examine and investigate existing concepts on sustainable development theory and practice, and review the relationships with and role of geospatial information.	Chapter 2: Literature review, practical experience.
2. Evaluate the evolution and development of geospatial information, its uptake at the intergovernmental level, applicability to the SDGs, existing mechanisms and initiatives; and identify issues and challenges impeding geospatial information from contributing more to sustainable development.	Chapter 3: Literature review, practical experience.
3. Investigate and evaluate the data flow - technology nexus, and the existence of the geospatial digital divide in developing countries.	Chapter 5 and 6: Literature, consultations with countries, case study.
4. Define and develop a conceptual national strategic geospatial information framework, with particular application to the geospatial requirements for measuring and monitoring the SDGs.	Chapter 7: Literature, consultations with countries, case study.
5. Demonstrate the utility and implementation of the national strategic geospatial information framework through a case study.	Chapter 8: Case study, consultations with countries.
6. Evaluate the improvement of the framework and identify areas for future work and directions.	Chapters 7-9: Case study, consultations with countries.

1.2.3 Research questions

In considering the research problem, aim and objectives as outlined above, the primary question that this research addresses is:

Research Question
<i>What challenges need to be considered and overcome for countries to establish nationally integrated geospatial information management practices so that geospatial information is able to contribute more holistically to support the implementation, measuring and monitoring of the SDGs?</i>

Breaking this overarching question down into smaller investigative pieces, several key research sub-questions need to be considered:

1. What is the current role and status of geospatial information in the global development agenda process, and why is it not readily understood or being mainstreamed in the implementation of the 2030 Agenda?
2. How can geospatial information systems, data flows and capabilities be integrated to analyse, model, manage, measure, monitor and disseminate all types of data to support national development and to bridge the geospatial digital divide?
3. What are the key issues to be addressed to ensure integrative strategic geospatial information management is achievable and sustainable?
4. What are the crucial elements of an integrated geospatial information framework, and can these elements be developed, tested and applied in a way that is generic enough for all countries to adopt, while overcoming the challenges and limitations of existing methods (including NSDIIs), and to provide an effective mechanism for all countries going forward?

1.3 About the Researcher

Before describing the justification for this research, and then the subsequent research approach chosen, it is pertinent to provide further context with regard to the background and motivations of the researcher. Firstly, the researcher brings to this dissertation considerable implied knowledge and experience in the field of geospatial information, not only in the many technical aspects, but especially in the integration of operational, applied research, science, strategic and policy-related national, regional and global geospatial outcomes. Much of this experience has been gained through more than 25 years of related work in Geoscience Australia, Australia's national earth sciences research agency, in a number of key roles and programmatic responsibilities. These include: leading and delivering Australia's national topographic mapping and geospatial programs and SDI initiatives; leading applied research to assess the risks from natural and anthropogenic hazards to Australian communities; developing the methodological approaches, tools and techniques to model critical infrastructure systems and processes; and leading Australian Government in a number of senior advisory roles on geospatial matters, including advisor to the Prime Minister's Science and Engineering Innovation Council (PMSEIC), the Australian Academy of Technological Sciences and Engineering, the National Counter Terrorism Committee, the Critical Infrastructure Advisory Council, and the Intergovernmental Committee for Surveying and Mapping (ICSM).

As Australia's national representative to the United Nations regional geospatial information processes, the researcher was also President of the United Nations Permanent Committee on GIS Infrastructure for Asia and the Pacific (PCGIAP) from 2008 to 2012, and President of the United Nations Regional Cartographic Conference for Asia and the Pacific (UNRCC-AP) from 2009 to 2012.

In early 2012, this experience and knowledge enabled the researcher to accept a posting in the United Nations Department of Economic and Social Affairs, Statistics Division, at the United Nations Headquarters in New York to establish the United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM) and grow its role and relevance with Member States and related International Organisations. Formally established by the United Nations Economic and Social Council (ECOSOC) in July 2011, the entire UN-GGIM apparatus, including its now mature mandates and global architecture, has been developed and nurtured by this researcher since the very first informal ideas and discussions were facilitated with the United Nations in 2009 (Van Halderen et al., 2016).

Secondly, this extensive background and relevant experience, combined with a realisation in 2012 that the United Nations needs to more urgently assist countries in their geospatial journey, has had a major influence on this dissertation, including its actual genesis, and has been exploited to its fullest as underlying tacit knowledge (and to some degree, acknowledged bias) that arguably few other researchers would readily possess. The origins of the research topic, and this subsequent dissertation, were borne from initial emotive frustration, that as the global development agendas were unfolding in the 2012-2015 period, some of the most basic needs and mechanisms for data access and use were not

being considered or understood. Through this dissertation, this frustration has since turned to more rational deductive reasoning, an applied research and pragmatic approach, to linking theory and practice, finding solutions to the problem, and finally to action. Interestingly, defining the problem and the supporting evidence did not prove difficult; determining an actionable solution has.

With regard to the problem (or frustration), this has had a particularly catalysing influence in determining this dissertation in two ways – and which are now more than 10 years in the making. The first was in 2009 when the researcher, whom was leading the regional United Nations geospatial initiatives for Asia-Pacific, became involved in trying to determine and articulate a sustainable global intergovernmental mechanism for geospatial information management under the auspices of the United Nations. This process is appropriately documented in Chapter 3 and will not be repeated here.

The second determining influence was a national Australian Government problem, one that to some degree remains today. In July 2010, the researcher was invited to lead a significant and innovative project to develop a national geospatial policy and governance framework for the Australian Government. Why? While realising measurable benefits in a number of areas, Government's considerable information holdings, often stored in many forms across individual agencies according to service delivery or policy responsibilities, were at the time still largely siloed. A familiar scenario. The majority of this information did not have a geospatial or consistent geographic reference, inhibiting easy discovery, access, integration and reuse. Where information had been linked to a location it had generally evolved in a fragmented and inconsistent manner, with duplication of effort, and with no clear whole-of-government direction, ownership or policy. The result increased the potential for sub-optimal decision-making and service delivery for Government. (Scott et al., 2011).

With high-level support and engagement by a number of Australian Government department heads, and after a year of research and national consultations with the support of a dedicated project team, the project report, known as the APS 200 Location Project Report, *Linking Information to Location*, was presented to the Australian Government through the Secretaries of the Australian Public Service (APS) in July 2011 as a case for change.

In producing the Report, the project team undertook a whole-of-government review of the creation, management, sharing, and utilisation of location information across Australian Government departments and agencies; developed a strategic framework that considered three critical areas: location information policy, governance, and investment; and recommended a range of measures to address the policy, governance and technical issues within a whole-of-government geospatial framework (Scott et al, 2011). The Report was both comprehensive and inclusive, and provided a detailed roadmap for the future of geospatial information assets in Australia. That Report to this day has not been formally made public, published nor appropriately acted upon. However, this researcher's published paper, aptly titled 'Are we there yet? Getting Australian Spatial Policy and Governance Right', was presented later in

2011 at the proceedings of the Spatial Sciences and Surveying Biennial Conference in New Zealand (Scott et al., 2011). The systemic geospatial challenges that existed and were identified in 2011 were actually the same geospatial challenges that existed around the world at national, regional and global levels.

1.4 Justification for Research

At the global level, the 2030 Agenda for Sustainable Development emphasised its adoption at a time of immense challenges to sustainable development; billions of the world's populations continue to live in poverty, are denied a life of dignity, and are subject to rising inequalities within and among countries, and with enormous disparities of opportunity, dignity, wealth and power. At the same time, the 2030 Agenda also emphasised that it is a period of immense opportunity and that significant progress had been made in meeting many development challenges (United Nations, 2015a, para. 14-15). For example, within the past generation hundreds of millions of people have emerged from extreme poverty, and access to education has greatly increased. Further, the spread of information and communications technology and global interconnectedness now provides great potential to accelerate human progress, to bridge the digital divide, to develop knowledge societies, and further scientific and technological innovation (United Nations, 2015a, para. 14-15).

With the implementation of the 2030 Agenda providing a priority and focus, this research identifies and addresses a persistent real-world problem of interest and global importance for many countries around the world who have limited capabilities and capacities to measure and monitor sustainable development, including targets and indicators, in a consistent and comparable manner. Achieving sustainable development requires an ambitious and transformational shift in measuring, monitoring, reporting – and targeted interventions.

Ironically, a transformative shift is also required in considering how the national geospatial information management capacities and policies, of developing countries in particular, can be improved and strengthened to support local to national development issues and approaches, which can then be aggregated and reported at regional and global levels. Countries desperately need geospatial methodological guidance, frameworks, tools, processes – and crucially, they need data. In order to build sustainable and resilient societies, policy-makers, the public and the private sector must have access to the right geospatial information to provide the evidence to inform good decisions; decisions such as how to reduce poverty and child mortality, build safer communities, protect infrastructure against climate change, sustainably manage forests, and protect coastal cities against sea level rise and future climate impacts (UN-GGIM, 2015a). Without high-quality data providing the right information on the right things at the right time; designing, monitoring and evaluating effective policies becomes almost impossible (United Nations, 2015b).

At its first intergovernmental session, held in October 2011, UN-GGIM stressed its commitment to the Rio+20 sustainable development discussions, and reflected on how it could take up the challenge and make a contribution to the forthcoming United Nations Conference on Sustainable Development in Rio de Janeiro in June 2012. This included considering the need for an integrative framework where very different types of information on the environment and socio-economic development could be integrated into a common framework. UN-GGIM noted that *“building such a common framework, which would allow us to link physical tangible and non-physical intangible data alike, and which would be critical for understanding the human/environment relationship, has been a daunting task for the various actors in sustainable development”* (UN-GGIM, 2011a, para. 5). The Committee also noted that it is increasingly recognised that geography and location, the physical platform where virtually all human activity takes place, provides the key linkage and an integrative geospatial framework for collecting, processing, storing and aggregating all types of data (UN-GGIM, 2011a).

At its fourth session, held in New York in August 2014, UN-GGIM observed that geospatial information is still limited by a lack of understanding about its use in sustainable development: *“Much has been achieved in promoting the use of reliable geospatial information for sustainable development over the past year. However, despite these continued and valuable efforts, the level of understanding and rate of uptake, particularly at the policy and decision-making level, remains less than optimal.....many do not understand its value and importance within the context of the sustainable development agenda....it surprisingly remains an unknown and complicated concept. The production and use of geospatial information within national, regional and global policy frameworks needs to be mainstreamed in order to enhance the capability for governments, international organisations and researchers to analyse, model, monitor and report on sustainable development, disasters, climate change, and other global concerns”* (UN-GGIM, 2014a, para 37).

With the theme ‘Sustainable Development with Geospatial Information’, UN-GGIM convened its Third High Level Forum in Beijing, China in October 2014 to examine how geospatial information may contribute more holistically to sustainable development. The Forum’s outcome document, the ‘Beijing Declaration’, agreed *“that geospatial information and products, are now more important than ever for providing the content and context for understanding natural and human systems, must contribute more to measure, monitor and manage sustainable development in a consistent way over time and be used for evidence-based decision and policy making”* (UN-GGIM, 2014b).

In his synthesis report on the post-2015 development agenda *The Road to Dignity by 2030*, the Secretary-General of the United Nations called for *“an evidence-based course for realising sustainable development and the complex challenges it presents”* and *“the world must acquire a new ‘data literacy’ in order to be equipped with the tools, methodologies, capacities, and information necessary to shine a light on the challenges of responding to the new agenda. Enhanced national and international statistical*

capacities, rigorous indicators, reliable and timely data sets, new and non-traditional data sources, and broader and systematic disaggregation to reveal inequities, will all be fundamental to implementing it.” (United Nations, 2014a, para. 140-141).

In its programme review of work for its first five years (2011 to 2015), submitted to ECOSOC in January 2016, UN-GGIM acknowledged that many challenges remain to enhance the understanding of the critical role and value of geospatial information in addressing local to regional and global issues. *“Although fundamental to measuring and monitoring the targets and indicators of the 2030 Agenda for Sustainable Development, the science-policy-data nexus, and related gaps in understanding, still pose challenges for the geospatial community in many Member States, particularly on how best to consolidate efforts in demonstrating how and where geospatial information can contribute to efforts in national agendas. Arguably, the role of geospatial information in contributing to sustainable development has not yet been adequately captured or described by the sustainable development policy practice, national geospatial information policy arrangements, or by the professional geospatial community. This means there is still a considerable requirement for continued outreach and awareness globally, as the need and demand for geospatial information capabilities is considerable and continues to increase”* (United Nations, 2016a, para 26).

The first annual report and global overview on progress towards the Sustainable Development Goals concluded with the following observations on improving data quality and availability: *“Data of good quality are vital for governments, international organisations, civil society, the private sector and the general public in order to make informed decisions and to ensure accountability for the implementation of the 2030 Agenda. That said, tracking progress on the SDGs requires the collection, processing, analysis and dissemination of an unprecedented amount of data and statistics at the subnational, national, regional and global levels, including those derived from official statistical systems and from new and innovative data sources. New data sources and technologies for data collection will need to be explored, including through partnerships with civil society, the private sector and academia. The integration of geospatial information and statistical data will also be essential for the production of a number of indicators”* (United Nations, 2016b, p.50).

Entering the fourth year of reporting on the SDGs, countries were realising how difficult it is to translate the shared vision of the 2030 Agenda into national development plans and strategies that ensure no one is left behind. In July 2018, in presenting the annual Sustainable Development Goals Report, the Secretary-General of the United Nations reiterated that *“without evidence of where we stand now, we cannot confidently chart our path forward in realising the SDGs. This reflects the “challenges faced in the collection, processing, analysis and dissemination of reliable, timely, accessible and sufficiently disaggregated data, calling for better evidence-based policymaking. While today’s technology makes it possible to collate the data we need to keep the promise to leave no one behind, we need political leadership, resources and commitment to use the tools now available”* (United Nations,

2018a). Not only do countries continue to lack important baseline data and enabling technologies to help guide development, national governments remain a considerable distance from fully developing and implementing the required policies and frameworks to ensure that development progress, including appropriate interventions, is effective, measurable and sustainable.

1.5 Research Design

This research is ‘applied research’ that seeks to improve the understanding of why geospatial information remains unable to adequately contribute its data, systems and integrative capabilities to support the measuring, monitoring and implementation of the SDGs – and to achieve a solution to the problem faced. The research has practical value and relevance to leaders in countries and their decision-makers in organisations. Given this and the justification for this research, the background and motivations of the researcher, and the research problem put forward earlier in this Chapter, this dissertation is designed and anchored according to the ‘research onion’ theoretical method developed by Saunders et al. (2009). This research method provides the necessary structure to integrate several layers of research and formulated considerations and findings in the course of conducting the research.

Considering the objective of this applied research is to deliver a descriptive dissertation based on deductive reasoning, a research philosophy, approach, strategy, and a case study; Saunders’ research onion was determined the most suitable structure. The research onion is a generic research procedure which helps depict issues underpinning the selection of data collection, research methods and a solution to the research problem (Saunders et al., 2009). Figure 1.1 presents the contents of the six onion layers, and through these, the elements of the research approach itself as highlighted.

The different layers, or ‘onion slices’, of the model represent the various stages through which the research must pass when putting together an effective methodology. At each stage, research considerations are able to be taken into account before the core of the onion, the data collection and data analysis, is addressed. By *peeling* back the layers of the research onion one by one, it has been possible to make decisions and choices at each stage in the research process, and this has culminated in the success of the research.

The elements chosen for each of the six layers of the research onion are briefly summarised below. Chapter 4 provides further details of the adopted research design and methodology to answer specific research questions and achieve the research aim and objectives put forward previously. The six different layers of the research onion are as follows:

- **Research philosophy:** Positivism and realism are the research philosophies chosen. Positivism was chosen as the dissertation uses a ‘mixed methods’ approach to the research as well as heightened levels of observation. Realism was chosen as it is a branch of epistemology which is similar to positivism, as it objectively assumes a scientific approach to the development of knowledge

(Saunders et al., 2009). This assumption underpins the collection of the data for this research, and the understanding of those data.

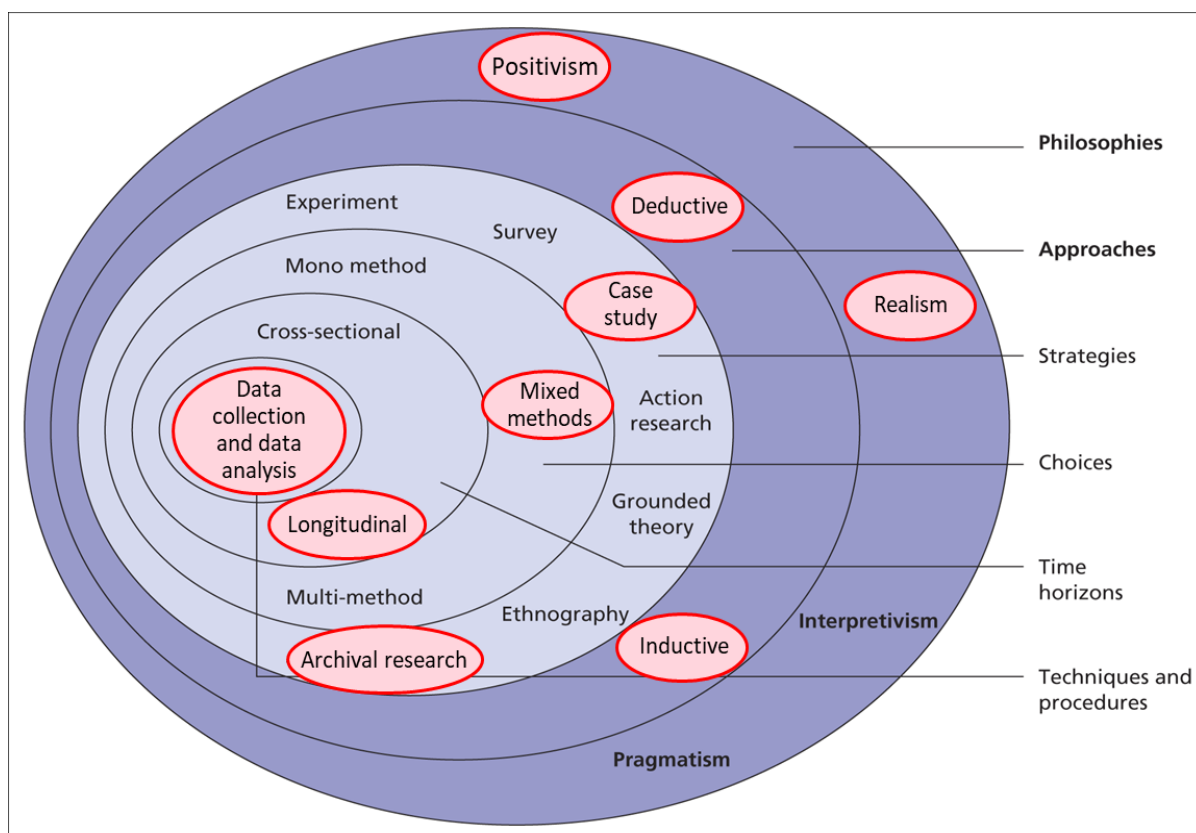


Figure 1.1: The six layers of the 'research onion' theoretical method developed by Saunders et al. (2009) with each of the elements adopted in this research (as indicated by the red circles).

- **Research approach:** Both deductive and inductive approaches have been used, although it is weighted more towards the deductive approach, as the research deduced a hypothesis – to develop a conceptual strategic framework – and then tested the operational hypothesis. Research using an inductive approach concerns the context in which events are taking place; in this research, the context of the 2030 Agenda and SDGs constitutes the events. Also, to some extent the theory was progressively developed and refined as data were collected.
- **Research strategy:** The research onion promotes the use of case studies and archival research methods. The case study, as detailed in Chapter 8, is primarily Africa, as an extreme and unique case, but also delves into a country example, Ethiopia, to tease out some of the issues to aid solving the research questions. The archival research, using administrative records and documents as the principal sources of data, comprises the detailed literature review detailed in Chapter 2 and Chapter 3 which, in turn, allows research questions to be analysed in terms of past experiences and learnings.

- **Research choice:** Based on the research questions and the researcher's objectives for this research, this dissertation employed mixed method research, with methods being triangulation (case study and archival research data collection methods) and complimentary.
- **Time horizon:** This dissertation employed a longitudinal time horizon, as it captured a significant amount of archival research (literature), and multiple consultations with actors involved in the case study over time.
- **Techniques and procedures:** The research was conducted using both primary and secondary data collection methods when researching the dissertation question. The national strategic geospatial information framework was first developed with inputs from secondary data, this input stemmed from the considerable literature review and general discussions conducted with global experts over the evolution of UN-GGIM (Chapter 2 and Chapter 3). With deductive analysis (from theory to data), primary data was collected and analysed against the conceptual framework to test the hypotheses. The primary data consisted of detailed discussions and interviews with experts, and numerous workshops and consultations in Africa and Ethiopia (Chapter 8).

1.6 Thesis Structure

Framed by the 2030 Agenda for Sustainable Development, as an integrated plan of action (detailed in Chapter 2), the major research components of the dissertation are presented in Figure 1.2, which provides the main reference point for the remaining Chapters. Figure 1.2 presents a geospatial roadmap towards the implementation of the 2030 Agenda and SDGs. These being: leveraging the role of geospatial data and enabling technologies (Chapter 3); being able to define and then bridge the geospatial digital divide (Chapter 5); the implementation of an integrated geospatial information systems framework (Chapter 6); and an overarching national strategic geospatial information framework (Chapter 7). These are linked to the structure and chapters of the dissertation (Figure 1.3).

The dissertation consists of nine Chapters structured in four parts, namely *introduction*, *background*, *research*, and *synthesis*, each of which may contain one or more Chapters as illustrated in Figure 1.3. The order and overall contents of each Chapter are briefly explained here.

Chapter 1: '*Introduction*' includes the statement of the research problem, the research aims, objectives, as well as the research questions. Justification for the research is explained and reasoned. In addition, the research structure and scope are detailed, and the research design is briefly described.

Chapter 2: '*Evolution of sustainable development*' examines and reviews the origins and evolution of sustainable development theory and practice from first concepts in the 1960s through to the present-day global development agenda, as applied to global United Nations system processes, and with a particular focus on geography and geospatial information. The Chapter also captures and discusses policy and practice signals of change that are of global importance for many countries around

the world, particularly the developing nations, who continue to struggle to measure and monitor sustainable development in a consistent manner.

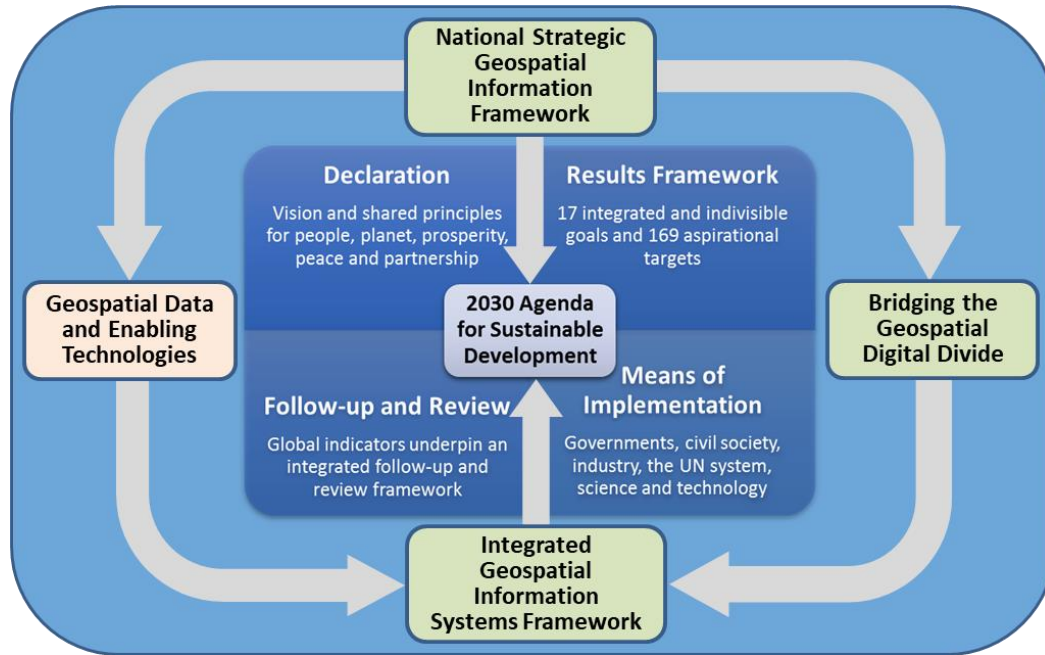


Figure 1.2: Framed by the 2030 Agenda for Sustainable Development, the major research components of the dissertation provide the main reference point for the remaining Chapters.

Chapter 3: *‘Geospatial information development and contemporary challenges’* describes the evolution and definitions of geospatial information, its understanding and uptake, contemporary geospatial information topics, technology development, integration challenges, its societal value, and applicability to the SDGs. The chapter describes the systemic problem with geospatial understanding and uptake at the policy level, and then focuses on the establishment of relevant regional to global geospatial information processes and mechanisms, including the establishment of UN-GGIM and related architectures.

Chapter 4: *‘Research design and methodology’* describes the followed methodology for the research in order to answer the research questions and achieve the desired research aim and objectives. The Chapter first investigates the research conceptual design framework by reviewing the research problem and questions, and then discusses and justifies the research method chosen to answer these questions.

Chapter 5: *‘Bridging the geospatial digital divide’* discusses the implications of the digital divide that continues to exist today for developing countries and introduces and describes the ‘geospatial digital divide’ and the complex challenges that continue to exacerbate the ability for these countries to bridge this divide. For developing countries, realising digital transformation still remains completely out of reach, as they are yet to attain effective and sustained access to digital technology, the Internet and the corresponding computer literacy and skills that are needed to take part in the information

society, to connect to the vast amounts of data and technology, and to orchestrate transformational change.

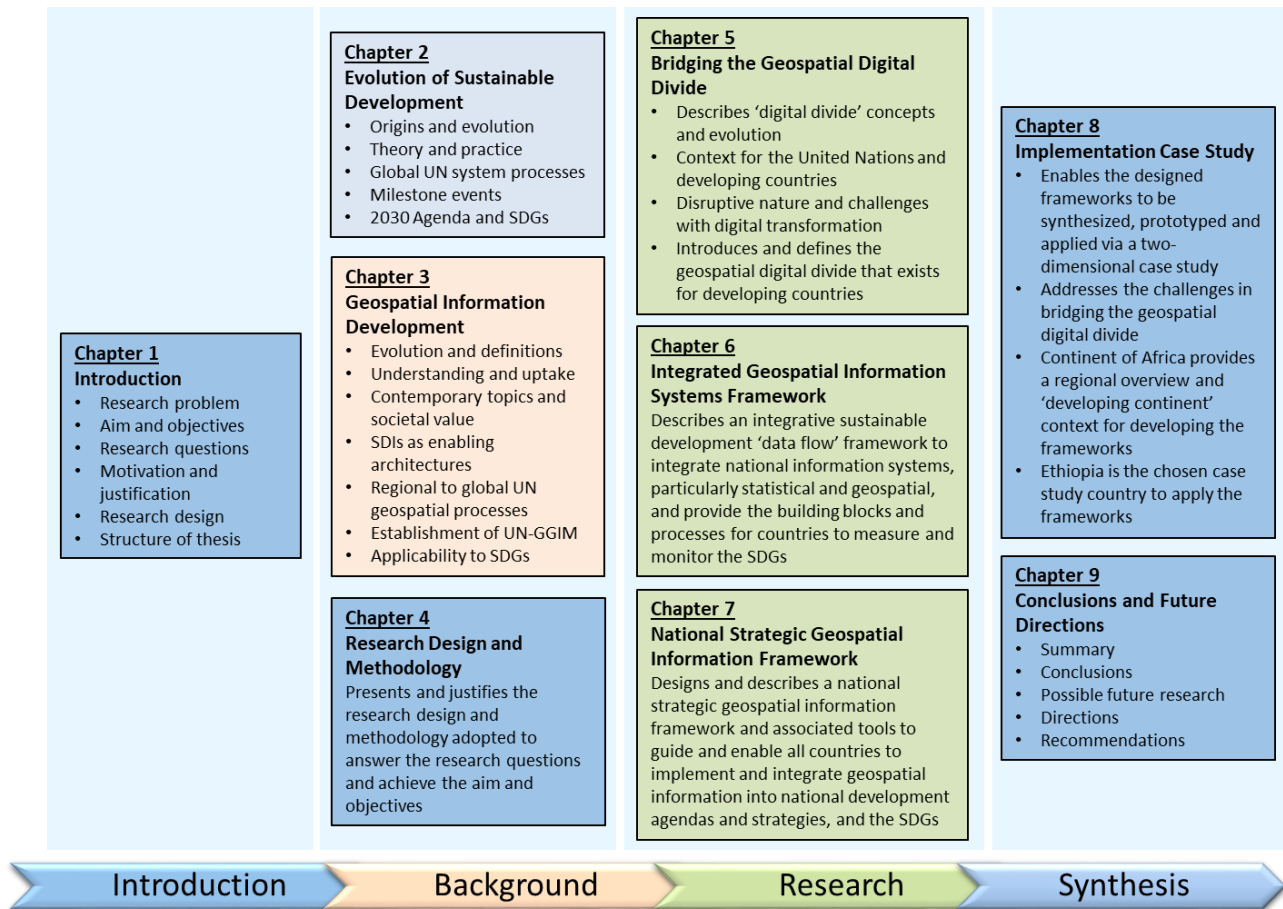


Figure 1.3: Structure and Chapters of the dissertation.

Chapter 6: *'Integrated geospatial information systems framework'* designs and describes a general Integrated Geospatial Information Systems Framework, an integrative sustainable development 'data flow' framework to provide the building blocks and processes for countries to measure and monitor the SDGs. The framework is able to integrate national information systems, particularly statistical and geospatial data, for reporting on the global indicator framework, from local real-world conditions to global harmonised reporting through robust and reliable data inputs.

Chapter 7: *'National strategic geospatial information framework'* designs and describes a National Strategic Geospatial Information Framework, consisting of a conceptual model, integrative framework and associated tools to guide and enable governments to implement and integrate geospatial information into national sustainable development policy agendas and strategies, and to contribute to country implementations of the 2030 Agenda. A key objective of the framework is to be able to translate global development policy down to national/local implementations through geospatial operating principles and strategic pathways.

Chapter 8: *‘Implementation case study’* enables the designed frameworks to be implemented and prototyped via a two-dimensional case study – regionally with Africa, and nationally with Ethiopia. The case study demonstrates how geospatial information can be integrated into national sustainable development policies and strategies. It will consider the role of the National Spatial Data Infrastructure (NSDI), as the national geospatial information system of the sustainable development data flow framework, as a means to provide reliable fundamental geospatial data, and to provide both the enabling platform and connection point to other national information systems and to the SDGs.

Chapter 9: *‘Conclusions and future directions’* reflects on the achievements of this research in addressing the original research problem, provides a summary, conclusions and recommendations, acknowledges the limitations of the research and proposes recommendations for further research, possible directions, and elaboration of the problem statement.

Chapter 2 – Evolution of Sustainable Development

2.1 Introduction

With the adoption of the 2030 Agenda for Sustainable Development, all countries unequivocally agreed that sustainable development challenges must be confronted immediately for the benefit of people, planet and prosperity. However, sustainable development, and its associated challenges, is not new or novel to the global community. Since its inception ‘sustainable development’ has evolved to mean different things to different people, and in some cases all things to all people. Hence it is a term that is as misunderstood as it is understood, has many different meanings, and therefore provokes many different responses (Hopwood et al., 2005; Adams, 2009; Shao, Li and Tang, 2011).

This Chapter examines the origins and evolution of sustainable development theory and practice, from first concepts to today’s implementation agenda, with a particular focus on geography and geospatial information. Whilst recognising the deep debates and ambiguities about the meaning of sustainable development, this dissertation uses the term ‘sustainable development’ to describe attempts to combine concerns with the environment and socio-economic issues in relation to humanity’s place on the planet. The reality is that sustainable development is driven by trade-offs, from local to global levels. While the conceptual model for sustainable development is of three separate, but connected, pillars: society, economy and environment; trade-offs must exist by default, and indicate a continued conceptual divide between the environment and humanity (Giddings et al., 2002). Giddings et al. (2002) argue that humanity is dependent on the environment, with society existing within, and dependent on, the environment, and the economy exists within society. Humans live within the environment and depend on it for survival and well-being; we cannot ignore the environment.

Although many conferences, fora and initiatives have transpired in the past 40+ years in many forms, this Chapter will only cite those that have provided the most significant contribution, as aligned to the mandates of the United Nations General Assembly, to determining and defining sustainable development, and in shaping the international agenda and global attitudes towards development.

2.2 Sustainable Development – Origins and Evolution

As discussed by Elliot (2006) and Adams (2009), sustainable development concepts have a long history in the literatures of both development and environmentalism, closely linked to the history of environmental concern and the conservation of nature in Western Europe and North America in the early 1960s. Early development concepts comprised a mixture of modernisation theories of economic development (Rostow, 1960) and interconnections between the environment, the economy and social well-being (Carson, 1962), creating a new public awareness that nature was vulnerable to human intervention and that the environment needed to be protected. However, by the end of the decade a number of influential future studies were predicting environmental destruction rather than protection. The most outspoken doomsday theorists (Ehrlich, 1968; Goldsmith et al., 1972; Meadows et al., 1972)

argued that the Earth had a finite capacity to sustain human civilization and that population growth and resource consumption were unsustainable unless drastic actions were implemented to balance human population, resource exploitation and the environment, and planetary limits.

Commissioned by the Club of Rome, *The Limits to Growth* (Meadows et al., 1972) was particularly provocative and influential due to the scientific analysis supporting the theories; a computer model simulated the consequences of interactions between the Earth's and human systems. With five variables: world population, industrialisation, pollution, food production, and resource depletion, Meadows et al. (1972) explored 12 scenarios to determine possible futures from 1972 to 2100. While the popular summary was seen as 'growth will come to an end' – environmental and economic collapse – within a century if 'business as usual' continued, the main scientific conclusion of the study was that delays in global decision-making would cause the human economy to overshoot planetary limits before the growth in the human ecological footprint slowed (Meadows et al., 1972). In defining the need to maintain the 'state of global equilibrium' the authors used "sustainable" when describing their search for a model output that represents a world system that is: 1) sustainable without sudden and uncontrolled collapse; and 2) capable of satisfying the basic material requirements of all of its people (Meadows et al., 1972). With more than 40 years of hindsight now available and as the world entered the period in which the original computer model simulation suggested the general onset of collapse first appears, at about 2015, updated and detailed comparisons are being made. Turner (2014) discusses whether the current economic difficulties of the global financial crisis are potentially related to mechanisms of breakdown in *The Limits to Growth* business as usual scenario.

While the above publications addressed issues relating to human interactions with the environment, and largely environmental in nature, the mainstream theoretical framework and understanding of sustainable development evolved in the 20-year period between 1972 and 1992 through a series of international conferences and initiatives led predominantly by the United Nations (Adams, 2009; Drexhage and Murphy, 2010). As indicated in the timeline provided in Figure 2.1, these evolving concepts of sustainable development were motivated by the growing awareness of the global links between mounting environmental problems, socio-economic issues to do with poverty and inequality, and concerns about a healthy future for humanity; concepts which today strongly link environmental and socio-economic issues (Hopwood et al., 2005). Due to its central role in global governance, and its ability to give all Member States the formal right to participate on equal terms in debates and decisions, the United Nations has been able to be a driving force in global efforts to translate these ideas into policy, and successfully provide this enduring global convening mechanism to deliver the voice of the many rather than of the few, and help set and steer economic, social, and environmental agendas and lay a foundation for expanded cooperation. The evolution of sustainable development, both as a concept and as a policy, has required that people from different continents, different world views,

YEAR	TIMELINE: SUSTAINABLE DEVELOPMENT ORIGINS AND EVOLUTION
1960	World population reaches 3 billion.
1962	Rachel Carson: 'Silent Spring' was considered a turning point in understanding the interconnections between the environment, the economy, and social well-being.
1968	Paul Ehrlich: 'Population Bomb' argued that the Earth had finite capacity; discusses the connection between human population, resource exploitation, and the environment.
1972	The Club of Rome: 'The Limits to Growth' predicts consequences if population growth and resource consumption is not slowed; systems analysis called for a state of global equilibrium. Goldsmith & Allen: 'Blueprint for Survival' warns of the breakdown of society and irreversible disruption of the Earth's life-supporting systems and called for a steady-state society. United Nations Conference on the Human Environment 'Stockholm Conference' held in Stockholm; first major conference to discuss environmental sustainability issues at global scale; momentum marked a turning point in the development of international environmental politics.
1974	World population reaches 4 billion.
1983	UN General Assembly establishes the World Commission on Environment and Development (WCED) to formulate a global agenda for change and to propose long-term environmental strategies for achieving sustainable development by the year 2000 and beyond.
1987	World population reaches 5 billion. WCED: 'Our Common Future' provides stark diagnosis of environment; advances the understanding of global interdependence and the relationship between socio-economic issues and the environment, and captures and popularizes the term "sustainable development."
1992	United Nations Conference on Environment and Development 'Earth Summit' held in Rio de Janeiro 20 years after Stockholm Conference; adopted Rio Declaration and Agenda 21, a global plan of action for sustainable development with 3 pillars – environmental, social and economic.
1993	UN Commission on Sustainable Development established to ensure follow-up on the Earth Summit; enhance international cooperation and monitor and report on implementation.
1997	UN General Assembly convenes a special session 'Earth Summit+5' to take stock of how well countries had responded to the 1992 Earth Summit and implementation of Agenda 21.
1999	World population reaches 6 billion.
2000	United Nations Millennium Summit held in New York; Millennium Declaration sets a series of time-bound and measurable goals to eradicate extreme poverty and hunger, empower women, reduce child mortality, combat diseases, and ensure environmental sustainability through 8 MDGs and 18 targets to be achieved by 2015.
2002	World Summit on Sustainable Development held in Johannesburg marked 10-year anniversary of the Earth Summit and reinvigorated the global commitment to an integrated approach to achieve sustainable development; specifically captured the need for geographic data and information systems in the Report of the Summit.
2011	World population reaches 7 billion.
2012	United Nations Conference on Sustainable Development 'Rio+20' held in Rio de Janeiro 20 years after the 1992 Earth Summit initiated the process to develop the Sustainable Development Goals, building upon the MDGs; outcome document 'The Future We Want' captured critical references on the need for geospatial information for sustainable development policymaking.
2013	UN General Assembly establishes a 30-member Open Working Group (OWG) on Sustainable Development Goals tasked with preparing a proposal on the SDGs for consideration by the General Assembly at its 68th session in September 2014; over 18 months period the OWG formulated a set of 17 proposed SDGs and 169 targets for the General Assembly.
2014	3rd Conference on Small Island Developing States adopts the 'SIDS Accelerated Modalities of Action (SAMOA) Pathway' in Apia, Samoa to support SIDS' sustainable development efforts.
2015	3rd UN World Conference on Disaster Risk Reduction adopts the 'Sendai Framework for Disaster Risk Reduction 2015-2030' in Sendai, Japan.
2015	United Nations Sustainable Development Summit, held in New York September 2015, adopts 'Transforming our World: The 2030 Agenda for Sustainable Development' to guide the way we pursue sustainable development to 2030; anchored by 17 SDGs, 169 targets and a global indicator framework to measure progress. Recognizes the need for high quality, timely, reliable and disaggregated data, including Earth observations and geospatial information.
2015	21st Session of the Conference of Parties (COP21) adopts the Paris Agreement on Climate Change in Paris, France; a universal agreement to reduce global warming.
2016	United Nations Conference on Housing and Sustainable Urban Development (Habitat III) adopts the 'New Urban Agenda' in Quito, Ecuador; to achieve sustainable cities and settlements.
2017	UN General Assembly adopts the Global Indicator Framework for the SDGs as the final piece of architecture for implementing and monitoring global progress on sustainable development.
2017	The UN Conference to Support the Implementation of SDG 14 'Ocean Conference', held in New York June 2017, adopts 'Our ocean, our future: call for action' to conserve and sustainably use our oceans, seas and marine resources for sustainable development.
2017	World population reaches 7.5 billion.

Figure 2.1: Timeline of sustainable development processes over the past half century.

and different expertise, but with a shared sense of the political sensitivities involved, find an institutionalised framework in which arguments lead to debate, debate to negotiations, negotiations lead to policy decisions, and such decisions eventually lead to action (Linner and Selin, 2013; Borowy, 2018).

2.2.1 UN Conference on the Human Environment (UNCHE)

The United Nations Conference on the Human Environment, convened in June 1972 in Stockholm, Sweden (also known as the Stockholm Conference), was the first major international conference to discuss and propose long-term environmental strategies for achieving sustainable development at the global scale (Borowy, 2018). Although, embedded in the pollution and acid rain difficulties of northern Europe at the time, the Conference created considerable momentum and marked a turning point in the development of international environmental politics, emphasising that defending and improving the environment must become a goal to be pursued by all countries (United Nations, 1972). Despite the basic dilemma of environmental protection in the face of widespread poverty and the need for economic development in large parts of the world (Borowy, 2018), the Declaration of the Conference called upon *“Governments and peoples to exert common efforts for the preservation and improvement of the human environment, for the benefit of all the people and for their prosperity”* (United Nations, 1972, p. 4) and outlined 26 principles pertaining largely to environmental protection, for countries to strive for.

While ‘sustainable development’ was not referred to explicitly, the essence of it was evident. It was realised that development needed to be sustainable – it should not focus only on economic and social matters, but also on matters related to the use of natural resources (Du Pisani, 2006). The preamble of the Declaration noted that *“to defend and improve the human environment for present and future generations has become an imperative goal for mankind – a goal to be pursued together with, and in harmony with, the established and fundamental goals of peace and of worldwide economic and social development”* (United Nations, 1972, p. 3). Principle 2 of the Declaration specifically alluded to managing the environment for the benefit of present and future generations: *“The natural resources of the earth, including the air, water, land, flora and fauna and especially representative samples of natural ecosystems, must be safeguarded for the benefit of present and future generations through careful planning or management, as appropriate”* (United Nations, 1972, p. 4). The Conference also produced the Framework for Environmental Action and created the United Nations Environment Programme (UNEP). Based in Nairobi, Kenya, UNEP continues to act and lead as a global catalyst for action to protect the environment by informing and enabling nations and peoples to improve their quality of life without compromising that of future generations.

2.2.2 UN World Commission on Environment and Development (WCED)

It was in the early 1980s when the United Nations General Assembly (General Assembly) began to discuss means to report on the environment, including proposed strategies for sustainable

development. Recognising the need to urgently address the growing concern over the “*accelerating deterioration of the human environment and natural resources and the consequences of that deterioration for economic and social development*” (Drexhage and Murphy, 2010, p. 7) the General Assembly (in its resolution 38/161) established the World Commission on Environment and Development (WCED) in December 1983 to formulate a global agenda for change and to propose long-term environmental strategies for achieving sustainable development by the year 2000 and beyond (WCED, 1987, p. ix).

In April 1987, Chaired by Norwegian Prime Minister Gro Harlem Brundtland, and following considerable global consultation, the Commission produced the landmark report *Our Common Future* (WCED, 1987). Also known as the Brundtland Report, *Our Common Future* not only provided a stark diagnosis of the state of the environment, it advanced the understanding of global interdependence and the relationship between the three fundamental components of sustainable development; the environment, the economy, and society, which later became known as the triple bottom line (Du Pisani, 2006). The Brundtland Report acknowledged the tension between economic growth and environmental protection. The Chair, in his Foreword, reaffirmed that “*the environment does not exist as a sphere separate from human actions, ambitions, and needs, and therefore it should not be considered in isolation from human concerns*” and “*the ‘environment’ is where we all live; and ‘development’ is what we all do in attempting to improve our lot within that abode. The two are inseparable*” (WCED, 1987, p. 7).

Our Common Future also introduced and captured what is now the classic definition of sustainable development:

‘development which meets the needs of the present without compromising the ability of future generations to meet their own needs’ (WCED, 1987, p. 43).

It contains within the definition two key concepts:

1. The concept of ‘needs’, in particular the essential needs of the world's poor, to which overriding priority should be given; and
2. The idea of limitations imposed by the state of technology and social organisation on the environment's ability to meet present and future needs (WCED, 1987, p. 43).

Here, ‘needs’ and ‘limits’ were seen as interconnected: while the aspirations of the poor majority of the world’s population to achieve a better life were entirely legitimate, extending the profligate resource consumption patterns of the rich countries to all would impose intolerable stress on global ecosystems (Meadowcraft, 2013).

The report stressed that humanity, whether in an industrialised or a rural subsistence society, depends for security and basic existence on the environment; that the economy and our well-being need the environment now and in the future (Hopwood et al., 2005). It also points to planet-wide

interconnections: environmental problems are not local but global, so that actions and impacts have to be considered internationally to avoid displacing problems from one area to another by actions such as releasing pollution that crosses boundaries, moving polluting industries to another location or using more than an equitable share of the Earth's resources (Hopwood et al., 2005). As a concept, sustainable development requires meeting the basic needs of all and extending to all the opportunity to satisfy their aspirations for a better life (WCED, 1987, p. 41). This suggests the need to balance two concerns, one having to do with present or intra-generational needs, and the other having to do with future or inter-generational needs (UNECE, 2005, p. 18).

In recognition of its global significance, UNEP adopted *Our Common Future* at its plenary meeting in June 1987, and further transmitted a draft resolution to the General Assembly for further consideration and adoption (United Nations, 1987a). The General Assembly, convinced of the importance of a reorientation of national and international policies towards sustainable development patterns, subsequently adopted *Our Common Future* at its forty-second session in December 1987 (United Nations, 1987b), giving sustainable development global political salience.

2.2.3 UN Conference on Environment and Development (UNCED)

In June 1992 global leaders laid the foundations for the global institutionalisation of *Our Common Future* at the 'Earth Summit', the United Nations Conference on Environment and Development (UNCED) in Rio de Janeiro, Brazil (Drexhage and Murphy, 2010). Convened 20 years after the Stockholm Conference, the Earth Summit sought to help governments rethink economic development, find ways to halt the destruction of irreplaceable natural resources and pollution, and to lay a foundation for a global partnership between the developing and the more industrialised countries, based on mutual needs and common interests, that would ensure a healthy future for the planet (Elliot, 2006).

In Rio, more than 178 Governments, 108 represented by heads of State, adopted the Rio Declaration on Environment and Development, and Agenda 21 – a global plan of action for sustainable development. The Rio Declaration contained 27 principles defining the rights and responsibilities of States, while Agenda 21 outlined a comprehensive programme for global action in all areas of sustainable development and included 40 separate chapters setting out actions in regard to the social and economic dimensions of sustainable development, conservation and management of natural resources, the role of major groups, and means of implementation (United Nations, 1992a). Chapter 40 of Agenda 21, pertaining to Information for Decision Making, recognised the critical importance of authoritative information on sustainable development issues in meeting the challenges of sustainable development. Two key programme areas of action were identified: bridging the data gap – the gap in the availability, quality, coherence, standardisation and accessibility of data between the developed and the developing world; and improving information availability – information within many countries is not adequately managed because of shortages of resources, lack of awareness of the value and

availability of such information, especially in developing countries. Even where information is available, it may not be easily accessible, either because of the lack of technology for effective access or because of associated costs (United Nations, 1992a). Chapter 40 concluded that the gap in the availability, quality, coherence, standardisation and accessibility of data between the developed and the developing world has been increasing, seriously impairing the capacities of countries to make informed decisions concerning environment and development (National Research Council, 2002).

As an objective – in the improvement of data collection and use – Agenda 21 noted that *“Countries and international organisations should make use of new techniques of data collection, including satellite-based remote sensing. In addition to the strengthening of existing development-related data collection, special attention needs to be paid to such areas as demographic factors, urbanisation, poverty, health and rights of access to resources, as well as special groups, including women, indigenous peoples, youth, children and the disabled, and their relationships with environment issues”* (United Nations, 1992a, para. 40.8).

Three instruments of environmental governance were also established: two legally binding Conventions aimed at preventing global climate change ‘The United Nations Framework Convention on Climate Change’ (United Nations, 1992b) and the eradication of the diversity of biological species ‘The Convention on Biological Diversity’ (United Nations, 1992c); and the non-legally binding ‘Statement of Forest Principles’ (United Nations, 1992d) – a set of principles to underlie the sustainable management of forests worldwide (Drexhage and Murphy, 2010).

The Earth Summit in Rio de Janeiro was unprecedented for a UN conference, in terms of both its size and the scope of its concerns. Hundreds of thousands of people from all walks of life were drawn into the Rio process. They persuaded their leaders to go to Rio and join other nations in making the difficult decisions needed to ensure a healthy planet for generations to come (Stavros et al., 2016). The Earth Summit influenced all subsequent UN conferences, which have examined the relationship between human rights, population, social development, women and human settlements – and the need for environmentally sustainable development (Stavros et al., 2016).

The UN Commission on Sustainable Development was also created at the Earth Summit to monitor and report on implementation of the agreements referenced above, and it was agreed that a five-year review of Earth Summit progress would be made at a session of the General Assembly (United Nations, 1992a). The General Assembly session, aptly named ‘Earth Summit+5’, was convened in New York in June 1997 and took stock of how well countries, international organisations and sectors of civil society had responded to the challenge of the Earth Summit (United Nations, 1997a).

2.2.4 UN Millennium Summit

Three years later, and again in New York, the General Assembly convened the ‘Millennium Summit’ in September 2000 in an attempt to seize a unique and symbolically compelling moment to

articulate and affirm a vision to ensure that globalisation becomes a positive force for all the world's people (Drexhage and Murphy, 2010). Attended by the largest gathering of world leaders in history, 149 Heads of State and Government and high-ranking officials from over 40 other countries, the Summit concluded with the 'Millennium Declaration' which contained a statement of values, principles and objectives for the 21st century (United Nations, 2000). The Declaration committed nations to a new global partnership to reduce extreme poverty and setting out a series of time-bound and quantified targets, with a deadline of 2015, which have become known as the Millennium Development Goals or MDGs. The 8 MDGs, which also included 18 targets and complemented by 48 technical indicators, were to: (1) eradicate extreme poverty and hunger; (2) achieve universal primary education; (3) promote gender equality and empower women; (4) reduce child mortality; (5) improve maternal health; (6) combat HIV/AIDS, malaria and other diseases; (7) ensure environmental sustainability; and (8) develop a global partnership for development (United Nations, 2000). However, the MDGs failed to recognise the need for data and geography and were therefore very limited in their ability to track and monitor progress consistently (United Nations, 2015c). These limitations will be considered in more detail in Chapter 3.

While representing challenges pertaining to the well-being of the Earth, sustainable development concepts to the end of the 20th century were largely dominated by environmental issues, including forests and climate, and were notably weaker (to this point) in addressing aspects related to social and economic development. However, this environmental emphasis meant that sustainable development also encapsulated many elements of geography and geospatial information. In 1998, Vice President Gore of the United States outlined the concept of a 'Digital Earth' (Gore, 1998). Gore presented compelling arguments for the application of geospatial information to the challenges to sustainable development which leant heavily on the use of location to link environmental information (UN-GGIM, 2012a). Then, in a symposium at the U.S. National Academy of Sciences in 1999, Professor John E. Estes suggested compiling a resource high-lighting the value of geographic data and tools for addressing issues of sustainable development, "*we cannot have sustainable economic development and improved environmental quality without understanding how our global resource base is changing through time*" (National Research Council, 2002, p. xi).

Building on the political momentum created by the UN Millennium Summit and its Declaration, and as a contribution to the upcoming World Summit on Sustainable Development, the U.S Department of State, through the National Academy of Sciences, commissioned a study to examine the geographic foundation for natural resource management and development issues in Africa. The subsequent report, *Down to Earth: Geographic Information for Sustainable Development*, draws on experiences in African countries and examines how future sources and applications of geographic data could provide reliable support to decision-makers as they work toward sustainable development. The report emphasised the potential of new technologies, such as satellite remote-sensing systems and geographic information

systems (GIS), which have revolutionised data collection and analysis over the last decade (National Research Council, 2002), and chartered the path for geographic data, Earth observations and GIS to address Chapter 40 of Agenda 21, pertaining to Information for Decision Making, in Section 2.2.3 above.

2.2.5 UN World Summit on Sustainable Development (WSSD)

The World Summit on Sustainable Development (WSSD), held in Johannesburg, South Africa, in September 2002, negotiations demonstrated a major shift in the perception of sustainable development – away from just environmental issues and more toward social and economic development (Drexhage and Murphy, 2010). This was driven by the needs of the developing countries, and strongly influenced by the MDGs adopted in 2000, focussing considerably more attention on development issues, particularly in integrating the MDGs with sustainable development principles and practices. Above all, the idea was to draw the environment into mainstream political and economic decision making (Meadowcraft, 2013).

The 2002 Summit reinvigorated at the highest political level the global commitment to achieve sustainable development (Elliot, 2006) and emphasised the importance of an integrated approach to sustainable development, including the need for quality data and information for decision-making. The Report of the Summit, under the topic ‘Means of Implementation’ specifically called for countries to, inter alia: *“promote the development and wider use of Earth observation technologies, including satellite remote sensing, global mapping and geographic information systems, to collect quality data on environmental impacts, land use and land-use changes, including through urgent actions at all levels to....access, explore and use geographic information by utilizing the technologies of satellite remote sensing, satellite global positioning, mapping and geographic information systems”* (United Nations, 2002, p. 67).

How geographic information and Earth observation technologies could actually be applied to sustainable development challenges, or be implemented, was aptly laid out and demonstrated within *Down to Earth: Geographic Information for Sustainable Development*. Although African countries were the geographic focus of the report, the material had broader applicability, demonstrating that geographic data and tools are central to addressing Agenda 21 action items, because they can be used to understand and integrate social, economic, and environmental perspectives, and they can address relationships among places at local, regional, national, and global scales (National Research Council, 2002). However, there was no apex intergovernmental mechanism in existence that could suitably address the production and use of geographic information within national, regional and global policy frameworks – or how they could be applied to sustainable development challenges.

2.2.6 UN Conference on Sustainable Development (UNCSD)

A decade later, and recognising that the MDGs were due to expire in 2015, the United Nations Conference on Sustainable Development (UNCSD), or Rio+20, was convened in June 2012 in Rio de Janeiro. Twenty years on from the 1992 Earth Summit (convened in Rio de Janeiro), Rio+20 was pivotal in that it sought to re-engage the world on a sustainable development pathway and initiate the process for a new development agenda for the future. The focused political outcome document, *The Future We Want*, contained clear and practical measures for implementing sustainable development, including setting the path to develop a set of Sustainable Development Goals (SDGs) to build upon the MDGs, and to converge with the post-2015 development agenda (United Nations, 2012a).

Critically, the *Future We Want* captured two specific references to geospatial information within the document's framework for action and follow-up, and through provision of means of implementation. These were specifically in the area of disaster risk reduction: "*We further recognise the importance of comprehensive hazard and risk assessments, and knowledge- and information-sharing, including reliable geospatial information*" (United Nations, 2012a, p. 36) and in the area of means of implementation – technology: "*We recognise the importance of space-technology-based data, in situ monitoring and reliable geospatial information for sustainable development policymaking, programming and project operations*" (United Nations, 2012a, p. 52).

Inclusion of these references were the result of considerable negotiation and influence by key global geospatial actors within countries, including this researcher whom also attended Rio+20 and convened a special side event titled 'Monitoring Sustainable Development – Why Location Matters'.² This event demonstrated the vital role accurate, maintained and reliable geospatial information can, and indeed is, playing in helping to deliver sustainable development across the globe and in providing financial benefits to users. With presentations based on real-country experiences, it illustrated why Member States should develop and leverage accurate and maintained geospatial information in order to deliver successfully on the outcomes of Rio+20 and to monitor the implementation of such outcomes effectively. The main target audience was senior government officials with decision responsibility on monitoring systems for sustainable development. (UN-GGIM, 2012b).

Although recognising the importance and need, the outcome document did not articulate how reliable geospatial information, including data and technologies, would be integrated into the many sustainable development policy and practice processes. While this was still to be determined, the post-2015 development debate provided a convergence moment for seizing the power and awareness of geospatial information within the global development community. At Rio+20, world leaders resolved to establish an inclusive and transparent intergovernmental process to develop the SDGs, stating that

² <http://ggim.un.org/meetings/2012-Brazil/>

they should be limited in number, aspirational and easy to communicate (United Nations, 2012). Further, the goals should address, in a balanced way, all three dimensions of sustainable development and be coherent with and integrated into the United Nations development agenda beyond 2015 (United Nations, 2012a, p. 47).

A 30-member Open Working Group on Sustainable Development Goals of the General Assembly (OWG) was established in January 2013 tasked with preparing a proposal on the SDGs for consideration by the General Assembly during its 68th session in September 2014 (United Nations, 2013a). Over an 18-month period, and predominantly through 13 intergovernmental sessions and related global consultations, the OWG formulated a set of 17 proposed SDGs, accompanied by 169 action orientated targets, to be attained by 2030. At its 68th session in September 2014, the General Assembly decided that the proposal of the OWG (United Nations, 2014b) would be the basis for integrating sustainable development goals into the post-2015 development agenda, while recognising fully that other inputs may also be considered in the intergovernmental negotiation process at the 69th session of the General Assembly (United Nations, 2014c). During the period January to July 2015, several intergovernmental negotiations on the post-2015 development agenda, and building on the proposal by the OWG, were convened by the General Assembly. These intense intergovernmental negotiations concluded on Sunday 2 August 2015, with Member States agreeing by consensus to adopt a new and transformational development agenda.

2.2.7 UN Sustainable Development Summit

The efforts of three years of global intergovernmental negotiations culminated in September 2015 when the General Assembly and world leaders adopted *Transforming our World: The 2030 Agenda for Sustainable Development* (United Nations, 2015a) at the United Nations Sustainable Development Summit held in New York from 25 to 27 September 2015. More than 150 world leaders attended and addressed the Summit. The formulation of *Transforming our World: The 2030 Agenda for Sustainable Development* (2030 Agenda) represents an agreed global and united development policy to guide the way all countries collectively manage and transform the social, economic and environmental dimensions of humanity and our planet in order to shift the world onto a sustainable and resilient path through to at least 2030. This new universal and transformative Agenda requires an integrated approach to sustainable development and collective action, at all levels, to address the challenges of our time, with an overarching imperative of ‘leaving no one behind’ and addressing inequalities and discrimination as the central defining feature (United Nations, 2015a).

2.2.8 Other UN Sustainable Development Processes

Although recognised as the major United Nations global development mechanism for implementation and measuring and monitoring sustainable development progress through to 2030, the 2030 Agenda is not a single policy, but is in fact informed by a number of other key global United

Nations system processes (Figure 2.2) which were also determined and adopted during the period 2014 to 2017. These include:

1. The SIDS Accelerated Modalities of Action (SAMOA) Pathway (United Nations, 2014d);
2. The Sendai Framework for Disaster Risk Reduction 2015–2030 (United Nations, 2015d);
3. The Addis Ababa Action Agenda on Financing for Development (United Nations, 2015e);
4. The Paris Agreement on Climate Change (United Nations, 2015f);
5. The new HABITAT III Urban Agenda (United Nations, 2016c); and
6. The Our Ocean, Our Future: Call for action (United Nations, 2017b).

2.2.8.1 Third UN International Conference on Small Island Developing States

The Third UN International Conference on Small Island Developing States was held in September 2014 in Apia, Samoa. The overarching theme of the conference was ‘The sustainable development of small island developing States (SIDS) through genuine and durable partnerships.’ The SIDS Accelerated Modalities of Action (SAMOA) Pathway adopted at the Conference addresses priority areas for SIDS and calls for urgent actions and support for SIDS’ efforts to achieve their sustainable development (United Nations, 2014d). This includes a recognition of the role that data and statistics play in development planning, and that improved data collection and statistical analysis are required to enable SIDS to effectively plan, follow up on, evaluate the implementation of, and track successes in attaining the internationally agreed development goals (United Nations, 2014d). The SAMOA Pathway specifically supported the efforts of SIDS to *“strengthen the availability and accessibility of their data and statistical systems, in accordance with national priorities and circumstances, and enhance their management of complex data systems, including geospatial data platforms, by launching new partnership initiatives or scaling up existing initiatives”* (United Nations, 2014d, p. 32).



Figure 2.2: Overarching broad and universal global development policy agenda accepted by all countries during the 2014 – 2017 period.

2.2.8.2 Third UN World Conference on Disaster Risk Reduction

Held in Sendai, Japan in March 2015, the Third UN World Conference on Disaster Risk Reduction was convened to complete the assessment and review of the implementation of the Hyogo Framework for Action and to adopt a concise, focused, forward-looking and action-oriented post-2015 framework for disaster risk reduction – the Sendai Framework for Disaster Risk Reduction 2015-2030 (United Nations, 2015d). The Sendai Framework recognises that to achieve the Framework’s four priorities for action it is important at the national and local levels *“to develop, periodically update and disseminate, as appropriate, location-based disaster risk information, including risk maps, to decision makers, the general public and communities at risk of exposure to disaster in an appropriate format by using, as applicable, geospatial information technology”* (United Nations, 2015d, para. 24(c)). At the global and regional levels *“to promote and enhance, through international cooperation, including technology transfer, access to and the sharing and use of non-sensitive data and information, as appropriate, communications and geospatial and space-based technologies and related services”* and *“disseminate risk information with the best use of geospatial information technology”* (United Nations, 2015d, para. 25(c) and (g)).

2.2.8.3 Third UN International Conference on Financing for Development

The Addis Ababa Action Agenda is the outcome document of the Third UN International Conference on Financing for Development convened in Addis Ababa, Ethiopia in July 2015, and consists of a new global framework and strong political commitment to address the challenge of financing and creating an enabling environment at all levels for sustainable development in the spirit of global partnership and solidarity (United Nations, 2015e).

2.2.8.4 21st Session of the Conference of the Parties

In December 2015, the 21st Session of the Conference of the Parties (COP21/CMP11) convened in Paris, France, and adopted the Paris Agreement, a universal agreement aimed at strengthening the global response to the threat of climate change; to keep a global temperature rise for this century well below 2 degrees Celsius and to drive efforts to limit the temperature increase even further to 1.5 degrees Celsius above pre-industrial levels and to foster climate resilience and low greenhouse gas emissions development (United Nations, 2015f). The Agreement recognises that climate change represents an urgent and potentially irreversible threat to human societies and the planet and thus requires the widest possible cooperation by all countries, and their participation in an effective and appropriate international response, with a view to accelerating the reduction of global greenhouse gas emissions (United Nations, 2015f).

2.2.8.5 UN Conference on Housing and Sustainable Urban Development

The *New Urban Agenda* was adopted at the United Nations Conference on Housing and Sustainable Urban Development (Habitat III) in Quito, Ecuador on 20 October 2016, and endorsed by the General Assembly on 23 December 2016 (United Nations, 2016c). To achieve sustainable cities and

human settlements, the *New Urban Agenda* presents a paradigm shift based on the science of cities; it lays out standards and principles for the planning, construction, development, management, and improvement of urban areas along its five main pillars of implementation: national urban policies, urban legislation and regulations, urban planning and design, local economy and municipal finance, and local implementation (United Nations, 2016c).

The Agenda recognises the need for an enabling environment and a wide range of means of implementation, including access to science, technology and innovation and enhanced knowledge-sharing, including “*The use of digital platforms and tools, including geospatial information systems, will be encouraged to improve long-term integrated urban and territorial planning and design, land administration and management, and access to urban and metropolitan services*” (United Nations, 2016c, para. 156) and “*the creation, promotion and enhancement of open, user-friendly and participatory data platforms using technological and social tools.....assisted by information and communications technologies, and geospatial information management*” (United Nations, 2016c, para. 160).

2.2.8.6 UN Conference to Support the Implementation of SDG 14

The UN Conference to Support the Implementation of SDG 14: Conserve and sustainably use the oceans, seas and marine resources for sustainable development (Ocean Conference), held in New York in June 2017, adopted *Our ocean, our future: call for action* to conserve and sustainably use our oceans, seas and marine resources for sustainable development (United Nations, 2017b). Recognition of this global process is important, as our “*ocean covers three quarters of our planet, connects our populations and markets and forms an important part of our natural and cultural heritage. It supplies nearly half the oxygen we breathe, absorbs over a quarter of the carbon dioxide we produce, plays a vital role in the water cycle and the climate system and is an important source of our planet’s biodiversity and of ecosystem services. It contributes to sustainable development and sustainable ocean-based economies, as well as to poverty eradication, food security and nutrition, maritime trade and transportation, decent work and livelihoods*” (United Nations, 2017b, para. 3).

2.3 The 2030 Agenda for Sustainable Development

The 2030 Agenda can be viewed as an ‘integrated plan of action’ through two lenses – the first being the five themes targeted as the blueprint to achieve sustainable development, and the second being the four pillars to implement the plan of action to achieve sustainable development. The first, achieving sustainable development, is a plan of action for people, planet, prosperity, peace and partnership (Figure 2.3), all of which are interlinked to sustainable development. The plan of action seeks to: eradicate poverty in all its forms and dimensions, including extreme poverty; protect the planet from degradation, including from sustainable consumption and production, sustainably managing its natural resources and taking urgent action on climate change, so that it can support the needs of the present and future

generations; ensure that all human beings can enjoy prosperous and fulfilling lives and that economic, social and technological progress occurs in harmony with nature; foster peaceful, just and inclusive societies which are free from fear and violence; and implement the Agenda through a revitalised global partnership based on a spirit of strengthened global solidarity, focused in particular on the needs of the poorest and most vulnerable and with the participation of all countries, all stakeholders and all people (United Nations, 2015a, p. 2).



Figure 2.3: The 2030 Agenda is an integrated plan of action for people, planet, prosperity, peace and partnership (United Nations, 2015a).

The four pillars of the 2030 Agenda, as an integrated plan of action, provide the overarching global context for what is needed to achieve sustainable development. As depicted in Figure 2.4, the four pillars comprise: (i) a vision and principles for transforming our world as set out in the Declaration; (ii) a results framework of 17 SDGs and 169 targets; (iii) a means of implementation through governments, civil society, global partnerships, and through science and technology; and (iv) a follow-up and review framework of global indicators to measure and monitor progress.

The 2030 Agenda is intentionally ambitious, providing a transformative and integrated approach to sustainable development, and is anchored by a set of 17 integrated and indivisible SDGs (Figure 2.5), 169 targets, and a global indicator framework (Appendix 1), in order to measure and monitor progress. It seeks to build on the MDGs and complete what they did not achieve. The SDGs and targets are integrated and indivisible, global in nature and universally applicable, taking into account different national realities, capacities and levels of development, and respecting national

policies and priorities. Targets are defined as aspirational and global, with each country setting its own national targets guided by the global level of ambition but taking into account national circumstances. Each country will also decide how these aspirational and global targets should be incorporated into national planning processes, policies and strategies (United Nations, 2015a, p. 13).

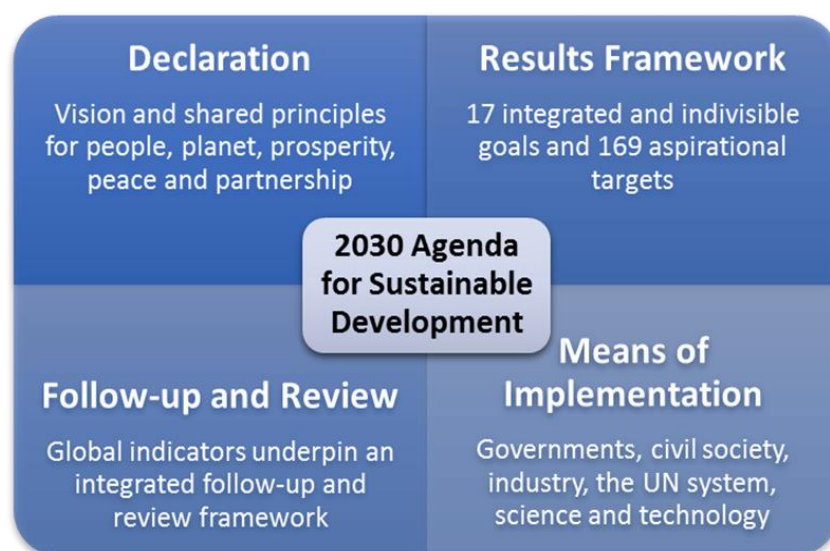


Figure 2.4: The four pillars of the 2030 Agenda, as an integrated plan of action, provide the overarching global context for what is needed to achieve sustainable development.



Figure 2.5: The 17 SDGs of the 2030 Agenda (United Nations, 2015a). Each SDG, with related targets and indicators, is detailed in Appendix 1.

2.3.1 2030 Agenda: Need for Geospatial Information

With considerable emphasis on countries being able to measure and monitor progress with good policy, science, technology and especially data, the broad and transformative nature of the 2030 Agenda

has ushered in a new era in thinking about sustainable development (Scott, 2018). Unlike its predecessor, the MDGs, the 2030 Agenda presents countries and the global policy community with a set of significant development challenges that are almost entirely geographic in nature (Scott and Rajabifard, 2017). By default, this requires new and innovative data sources and integration approaches to address development challenges and to ‘leave no one behind’.

While posing tremendous challenges for all countries, and considerably more so for developing countries, the 2030 Agenda also provides tremendous focus and opportunity to respond to the unprecedented demand for more, and new sources of, data covering all countries and all aspects of development. Geospatial information, as an enabling technology and information system, is able to provide a set of science and time-based monitoring solutions to these challenges, driven by data and with ‘geography’ as context. As noted by UN-GGIM (2012a, p.2): *“All of the issues impacting sustainable development can be analysed, mapped, discussed and/or modelled within a geographic context. Whether collecting and analysing satellite images or developing geopolitical policy, geography can provide the integrative framework necessary for global collaboration and consensus decision making.”*

In this respect, the 2030 Agenda captures specific references to the need for high quality, timely, reliable and disaggregated data, including Earth observations and geospatial information, in the area of follow up and review: *“We will support developing countries, particularly African countries, LDCs, SIDS and LLDCs, in strengthening the capacity of national statistical offices and data systems to ensure access to high quality, timely, reliable and disaggregated data. We will promote transparent and accountable scaling-up of appropriate public-private cooperation to exploit the contribution to be made by a wide range of data, including earth observation and geospatial information, while ensuring national ownership in supporting and tracking progress”* (United Nations, 2015a, p. 32). These data needs are elaborated through an associated goal, target and date, as described in Goal 17 in the area of data, monitoring and accountability: *“By 2020, enhance capacity-building support to developing countries, including for least developed countries and small island developing States, to increase significantly the availability of high-quality, timely and reliable data disaggregated by income, gender, age, race, ethnicity, migratory status, disability, geographic location and other characteristics relevant in national contexts”* (United Nations, 2015a, p. 27).

This researcher played a leading role in negotiating and ensuring that this language was included in the final text of the 2030 Agenda. It built upon a critical side event on the role of geospatial information in sustainable development convened during the post-2015 intergovernmental negotiations with Member States by the OWG in April 2015 as the SDGs were being developed. The side event titled ‘Unleashing the power of ‘Where’ to make the world a better place: How geographic information contributes to achieving the sustainable development goals’ demonstrated the importance of geospatial information and Earth observations in measuring and monitoring the implementation of the SDGs (UN-

GGIM, 2015a). A short, but impactful video titled ‘Everything that happens, happens somewhere’³ was also produced by the researcher for the side event to showcase the value of geographic location in showing where social, environmental and economic conditions occur; and how having reliable and authoritative geospatial information provides the framework for measuring, monitoring and achieving the SDGs, enables better decision-making by providing information about people and the planet, and contributes to tackling global problems such as poverty, hunger, disease, deforestation, land management, climate change, improving people’s lives and protecting the planet (UN-GGIM, 2015a).

The adoption of the 2030 Agenda has provided the global policy mandate for all countries to exploit the contribution to be made by geospatial information to support the SDGs, targets and global indicators, and all of which are highly dependent on diverse, reliable and repeatable data to provide the evidence base for policy, decision-making and reporting on the health and wellbeing of our planet on an ongoing basis (Scott and Rajabifard, 2017). Further, it has articulated the need for all countries by 2020 to increase significantly the availability of high-quality, timely and reliable data disaggregated by income, gender, age, race, ethnicity, migratory status, disability, geographic location and other characteristics relevant in national contexts; and do so by addressing the capacities of the LDCs and SIDS first (United Nations, 2015a). But does this provide enough for countries to implement change and achieve the mandate for the geospatial community to be mainstreamed into sustainable development?

In negotiating this critical outcome document, the political decision-makers and diplomats from Member States were primarily concerned with agreeing on important global and national issues: hunger, poverty, disease, urbanisation, water scarcity, land management, climate change, disasters and other environmental challenges. That was rightly their lens. However, it can immediately be recognised, through a location lens, that geography is linked to many, if not all, of the SDGs. But what and where is the relevance and benefit, and what does this really mean for the geospatial professional community in Member States? Further, how will these important issues be measured and monitored? What are the signals or indicators of progress being made? What is the framework? Is there a geographic context? Where is the evidence coming from? How do we identify where these social, environmental and economic conditions occur? Where does geospatial information fit? What is the role of national mapping and other related agencies in Member States?

The following Chapters will come back to these questions, but first it is valuable to consider where geospatial information fits in the global sustainable development dialogue, and the one greatest geospatial information policy challenge that continues to plague us – awareness. Despite the significant advances in geospatial and disruptive technologies, location-based services, satellites, positioning

³ <https://www.un.org/development/desa/publications/video/everything-that-happens-happens-somewhere>

systems, ubiquitous data, the data revolution, big data, the web, etc. there is still a lack of awareness, understanding and uptake, particular at the policy and decision-making level, of the vital and integrative role of geospatial information (Scott and Rajabifard, 2015, 2017) and the ‘opportunity’ it provides to all countries in the sustainable development agenda. In some respects, this is a reflection of the considerable policy – technical gap that exists within and across countries, but it is also a reflection of the different philosophies of each community. Achieving sustainable development is driven by the need for political negotiation and agreement in order to obtain high level global objectives for the future of the planet. The geospatial information philosophy is more concerned with ensuring reliable and authoritative local to national data and science-based analyses are available on the interactions of people with their places and environment. Therefore, there are obvious differences in understanding and in terminologies, especially in the growing data requirements to support the many social, economic and environmental dimensions of sustainable development, including measuring and monitoring. Fortunately, these differences are slowly being brought together through change – motivated partly by awareness and understanding, but now more so, as time passes, by pure necessity as valuable lessons are being learned.

The adoption of the 2030 Agenda corresponded with the conclusion of the MDGs. The final *Millennium Development Goals Report* was a key report that summarised 15 years of concerted effort and significant progress in lifting more than one billion people out of extreme poverty (United Nations, 2015c). The MDG Report also provided an opportunity to reflect on some of the important shortfalls encountered and numerous lessons learned as the world tried to achieve the eight aspirational goals. The major lesson – data are an indispensable element of the development agenda (United Nations, 2015c). Despite significant and recognised global achievements, the MDGs failed to recognise the need for data and geography and were limited in their ability to track and monitor progress consistently. In essence, there was no sustainable data to measure and monitor sustainable development. Many of these reflections are highly relevant to the arguments pertaining to geospatial information contained within frame of this dissertation. These include:

- Real data improvement occurs when demand and policy support meet;
- Despite improvement, critical data for development policymaking are still lacking;
- Real-time data are needed to deliver better decisions faster;
- Geospatial data can support monitoring in many aspects of development, from health care to natural resource management;
- New technology is changing the way data are collected and disseminated;
- Global standards and an integrated statistics system are key elements for effective monitoring; and
- Data should be open, easily accessible and effective for development decision-making (United Nations, 2015c).

In the area of ‘Geospatial data can support monitoring’ the report specifically acknowledged the importance of geospatial information: *“Knowing where people and things are and their relationship to each other is essential for informed decision-making. Comprehensive location-based information is helping Governments to develop strategic priorities, make decisions, and measure and monitor outcomes. Once the geospatial data are created, they can be used many times to support a multiplicity of applications”* (United Nations, 2015c, p.12).

2.3.2 2030 Agenda: Learning from Four Years of Implementation

On 1 January 2016, the world officially began implementation of the 2030 Agenda. Reflecting on four years of measuring, monitoring and reporting on this implementation, where do we stand and what progress have we made? Ironically, there was first a need to determine ‘what’ would be measured and by which parameters or metrics. As indicated in Figure 2.4, the 17 SDGs and 169 targets were agreed upon through the political process by the General Assembly and are coded into the 2030 Agenda. The 17 SDGs comprise the integrated and indivisible global goals to be achieved by countries, and applicable for both developed and developing countries, balancing the three dimensions of sustainable development. The 169 targets provide the detailed and actionable objectives for countries to measure progress through to 2030. Each country sets its own national targets, guided by the global level of ambition, and decides how these targets should be incorporated into national planning processes, policies, strategies and frameworks (United Nations, 2015a).

Because of their technical and detailed nature, the task of determining the global indicator framework was given to the United Nations Statistical Commission by the General Assembly. In terms of a robust and annual follow-up and review mechanism for the implementation of the 2030 Agenda, it is the global indicator framework which determines where the data acquisition, integration and disaggregation will be most needed, and what the specific data requirements will be (United Nations, 2016d).

In 2015 the Statistical Commission established the Inter-agency Expert Group on Sustainable Development Goal Indicators (IAEG-SDGs) to develop the global indicator framework as the quantitative means by which countries can consistently measure and monitor achievement on, and report progress towards, each of the 169 targets (United Nations, 2016d). The real data inputs and subsequent outputs, and hence accountability for results, will be through the global set of indicators which rely entirely on real-world data – statistics, geospatial, Earth observations, and other Big Data (Figure 2.6) – on a range of social, economic and environmental metrics. How this is able to be achieved, via an integrative sustainable development ‘data flow’ framework to provide the building blocks and processes for countries to measure and monitor the SDGs, is detailed in Chapter 6 of this dissertation.

In July 2017 the global indicator framework was adopted by the General Assembly and comprises an initial 232 indicators (Appendix 1), which will be reviewed from time to time and especially in 2020 and 2025. However, it is acknowledged that the constraints faced by many developing countries in producing the data necessary to address the indicator requirements will remain an ongoing capacity issue for some time, if not indefinitely (United Nations, 2017c).

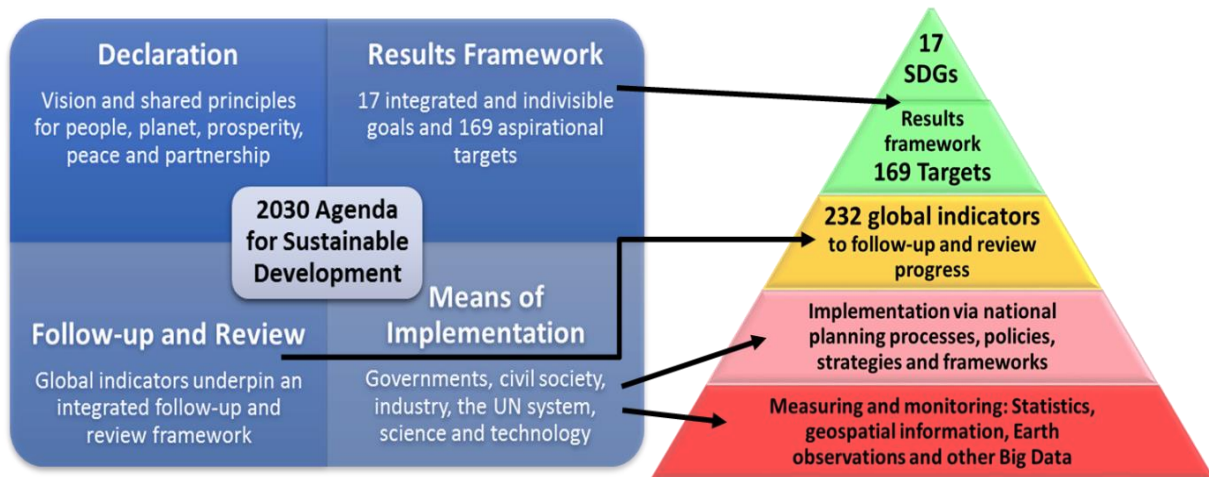


Figure 2.6: Any national SDG implementations will be sub-optimal without processes, policies, strategies and frameworks to integrate statistics, geospatial information, Earth observations and other Big Data into the measuring, monitoring and reporting processes.

In determining the global indicator framework, countries acknowledged that baseline data for a number of the targets and indicators remain unavailable, indicating that the data paradox is indeed a reality; requiring increased support for strengthening data collection and capacity development to develop national and global baselines. There is also a recognition of the need to democratise the enabling technologies and liberate much of the associated data that is available in such a way that they are easily reachable and useable by developing countries. Historically, relatively little attention has been paid to the challenges these countries face in effectively collecting and producing data, and in building and strengthening their capacities within the national geospatial agencies and statistical offices. With the enabling global mechanism of the 2030 Agenda, the challenge is how to most effectively transfer the available technology, data richness, and connectivity to the technology and data poor (Scott, 2018). This data and technology ‘digital divide’ connectivity is discussed in Chapter 5 of this dissertation.

The first report on progress on the SDGs, *The Sustainable Development Goals Report 2016* (United Nations, 2016b) was released in July 2016 at the United Nations High Level Political Forum on Sustainable Development by the Secretary-General. This report will be released annually through to 2030 in this method, providing the world a snapshot of global development progress. In introducing the report the Secretary-General reiterated “*how important coordinated global data-generation efforts will be in supplying reliable and timely data for systematic follow-up and progress reviews*” (United Nations, 2016b, p.2). With regard to improving data quality and availability, “*tracking progress on the*

SDGs requires the collection, processing, analysis and dissemination of an unprecedented amount of data and statistics at subnational, national, regional and global levels, including those derived from official statistical systems and from new and innovative data sources. The integration of geospatial information and statistical data will be particularly important for the production of a number of indicators” (United Nations, 2016b, p.50).

The 2017 report, *The Sustainable Development Goals Report 2017* (United Nations, 2017a) shows that the rate of progress in many areas is far slower than needed to meet the SDG targets by 2030. The Secretary-General stressed that high-level political leadership and new partnerships will be essential for sustaining momentum. He also “*underscores the need for reliable, timely, accessible and disaggregated data to measure progress, inform decision-making and ensure that everyone is counted*” (United Nations, 2017a, p. 2). In a dedicated section on ‘Harnessing the power of data for sustainable development’ the report noted that in order to leave no one behind, “*national statistical systems need to invest in the technology and skills necessary to collect and integrate data from multiple sources, including integration of geospatial information with statistics and other data. This means making better use of traditional statistical surveys, censuses and administrative records. It also means harnessing the power of technology to leverage new sources of data, such as from cell phone records, Earth observations, other sensors and social media. More citizen-generated data are also being used to monitor the needs and progress of vulnerable groups. However, new methodologies need to be developed to ensure the quality and reliability of such data*” (United Nations, 2017a, p. 14).

Entering the fourth year of reporting on the SDGs, countries are realising how difficult it is to translate the shared vision of the 2030 Agenda into national development plans and strategies (UN-GGIM, 2019a). In July 2018, in presenting the annual *Sustainable Development Goals Report 2018*, the Secretary-General reiterated that without evidence of where we stand now we cannot confidently chart our path forward in realising the SDGs. This reflects the “*challenges faced in the collection, processing, analysis and dissemination of reliable, timely, accessible and sufficiently disaggregated data, calling for better evidence-based policymaking. While today’s technology makes it possible to collate the data we need to keep the promise to leave no one behind, we need political leadership, resources and commitment to use the tools now available*” (United Nations, 2018a, p.3).

There are common threads of learning evolving. Firstly, do we really understand the scale and dimensions of the world’s development problems, where they are, whom they impact, what are the causes, and how they can be remedied? In the pursuit for sustainable development, many countries continue to face a series of impediments that exacerbate their ability and ‘opportunity’ to participate fully in the implementation of the 2030 Agenda, to support national development, economic prosperity, and through that, a global and thriving information economy.

Secondly, what are the data needs to measure progress, where is that data, and what are the policy and data frameworks and methods to enable its realisation? To be able to measure and monitor progress for those most in need, the most vulnerable countries, will require transformative change, not only in delivering on such a broad and ambitious agenda, but also in how the right data, *high quality, timely, reliable and disaggregated data*, is brought to bear to measure and monitor progress and to overcome significant social, economic and environmental challenges that are almost entirely geographic in nature (Scott and Rajabifard, 2017; UN-GGIM, 2019a).

Thirdly, not only do countries continue to lack important baseline data and enabling technologies to help guide development, national governments remain a considerable distance from fully developing and implementing the required policies and frameworks to ensure that development progress, including appropriate interventions, is effective, measurable, and sustainable. The 2030 Agenda has articulated the need for countries to increase significantly the availability of high-quality, timely and reliable data disaggregated by a number of characteristics relevant in national contexts by 2020 (United Nations, 2015a). Meeting these new data requirements is already proving difficult for the most advanced countries, but for the developing countries, particularly African countries, LDCs, SIDS, and land-locked developing countries, the challenges faced in the collection, processing, production, analysis and dissemination of reliable, timely, accessible and sufficiently disaggregated data for better evidence-based policymaking are significant and not to be underestimated (United Nations, 2018a).

2.4 Chapter Summary

The objectives of this Chapter were to provide insights into global sustainable development challenges and processes over the past half century (as summarised in the timeline in Figure 2.1), how they are closely inter-related with geography, and to demonstrate that the global geospatial information community, through national geospatial information agencies, has a unique opportunity to integrate and connect geospatial information into the global development agenda in a more holistic and sustainable manner. The 2030 Agenda for Sustainable Development provides a new global and transformative policy to guide the way we pursue sustainable development in the coming 15 years. It has determined a set of 17 SDGs and 169 targets and defined a process for all countries to measure and monitor progress towards implementation through a global indicator framework that is highly dependent on diverse and reliable data to provide the evidence base for decision-making and reporting. For the first time in such global processes, the need for both geospatial information and Earth observations are well articulated (Scott and Rajabifard, 2015, 2017). The national to global policy need, demand and mandate has been demonstrated.

The next Chapter describes the evolution and definitions of geospatial information, its understanding and uptake, contemporary geospatial information topics, technology development, integration challenges, its societal value, and applicability to the SDGs. The Chapter describes the

systemic problem with geospatial understanding and uptake at the policy level, and then focuses on the establishment of relevant regional to global geospatial information processes and mechanisms, including the establishment of UN-GGIM and related architectures.

Chapter 3 – Geospatial Information Development and Contemporary Challenges

3.1 Introduction

In order to consider both ‘geospatial information’ itself, and then its use to support the sustainable development agenda, the objective of this Chapter is to compare and relate the development of geospatial information more broadly, with the development of geospatial information development within the intergovernmental processes of the United Nations. Therefore, this Chapter will investigate and evaluate the evolution and development of geospatial information; its understanding and uptake at the governmental and policy level; the establishment of relevant United Nations’ regional to global geospatial information processes and mechanisms such as UN-GGIM; their applicability to the SDGs; and will identify the issues, challenges and impediments to geospatial information contributing more holistically to sustainable development. For comparison and context with sustainable development, it is relevant to consider and explore the pioneers and advent of geographic information systems (GIS), the geospatial technology evolution, the emergence and role of Spatial Data Infrastructures (SDIs), and contemporary geospatial information topics and ‘disruptors’ of change, such as: digital transformation, the Data Revolution, Big Data, cloud computing, the Internet of Things, Artificial Intelligence, comparison of authoritative and citizen data, statistics and geospatial information, and the need for greater data integration and synthesis. This Chapter addresses the ‘Geospatial Data and Enabling Technologies’ component of the dissertation as illustrated by Figure 1.2 in Chapter 1.

Dempsey (2012) proposed four distinct phases of geospatial information evolution when considering the history of GIS. These have been modified and built upon as a means to shape the outline of this Chapter (Figure 3.1). The first phase, the pioneering age, from the early 1960s to the mid-1970s, saw a new geographic discipline emerge and being dominated by a few key individuals who were to shape the direction of future research and development. The second phase, from the mid-1970s to the early 1980s, saw government-funded experimental research and the regularisation and adoption of technologies within and by national agencies that led to a focus on the development of best practice. Phase three, between 1982 until the late 1980s, saw the development and exploitation of the commercial market place surrounding GIS (Dempsey, 2012). The fourth phase, from the late 1980s to mid-2000s, saw a focus on user dominance facilitated by competition among vendors, standardisation among open systems, and ways of improving the usability of technology by making facilities more user-centric (Coppock and Rhind, 1991; Crompvoets et al., 2004; Dempsey, 2012; Waters, 2017). The present fifth phase represents the ‘digital transformation’ towards mass consumerism of geospatial information and location-based services, and technologies as a key component of the Fourth Industrial Revolution. This phase has grown in prevalence over the past decade.

3.2 The Pioneers and Evolution of GIS

In an almost parallel universe to that described for sustainable development in Chapter 2, the first concepts of geospatial information also originated in the early 1960s and, although not realised at

the time, were conceived and developed in order to better understand and report on environmental sustainable development and the integration of mapping and statistical information. What was also not realised were the efforts occurring simultaneously in a number of research laboratories on different continents, primarily in North America and the United Kingdom, with minimal cross-fertilisation and almost no awareness of the valuable work each were doing. Part of this lack of awareness was due to the fact that the communication technology then was not what it is today, but perhaps more importantly, the researchers involved were completely immersed in the problems at hand (Deakin, 2009, p. 243). Moreover, as Chrisman (1988) and Rhind (1988) observe, those individuals, and their activities in universities in this field in the early stages of the development of GIS, were often outside the formal academic career structure and were so heavily involved in project work that they had little time or inclination, let alone any obvious outlets to publish on such a novel topic, to write papers or communicate otherwise.

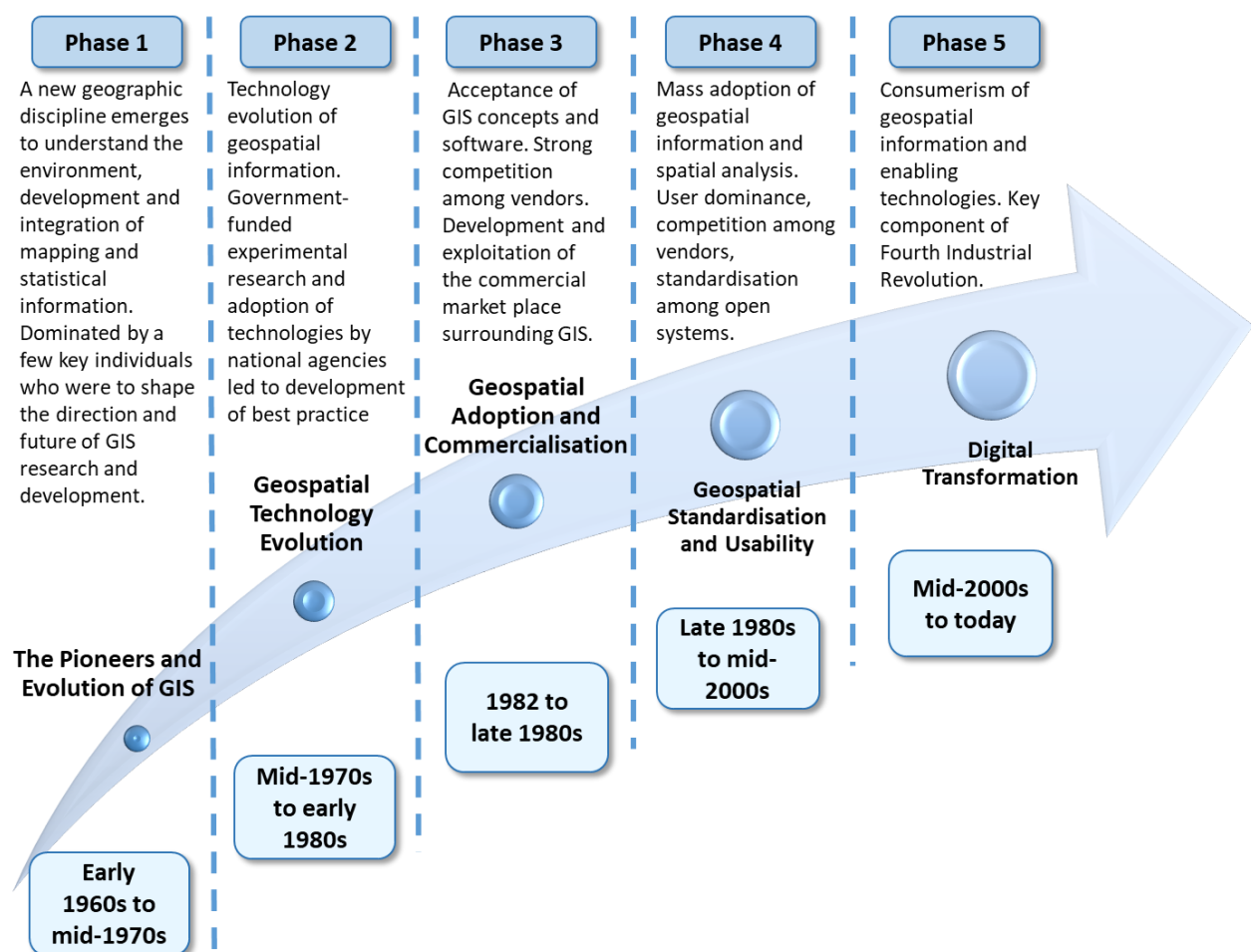


Figure 3.1: The five phases of geospatial information evolution. Modified after Dempsey (2012).

Acknowledging the paucity of documented evidence at the time, a special issue of *The American Cartographer* (1988) on the digital revolution in cartography, and then invaluable publications by Maguire et al. (1991), Foresman (1998) and Chrisman (2006) have recorded and

reflected, with many personal perspectives from the individuals concerned, on much of the historical background to the pioneering and development of GIS; some with a focus on vector representations, and some from a raster perspective (Onsrud and Kuhn, 2016). A review of that history suggests that in the 1960's a very small group of particular individuals and institutions, motivated by overcoming challenges when faced with the possibility of using new sources of data and techniques, played instrumental roles in developing GIS and the early concepts geospatial data. These included: Roger Tomlinson in the Canada Geographic Information System, Howard Fisher in the Harvard Laboratory for Computer Graphics, and Jack Dangermond in the Environmental Systems Research Institute in North America; and David P. Bickmore at the Experimental Cartography Unit in the United Kingdom (Coppock and Rhind, 1991, p. 23).

In Canada, Tomlinson (1962, 1963) introduced the use of electronic computers in the storage, compilation and assessment of natural and economic map and statistical data in 1962 for the evaluation of marginal agricultural lands in Canada to: *"initiate studies regarding the application of computers to the storage, compilation and assessment of map data as well as statistical data, and to the production of accurate and specific correlations between the two types of data... so that all factors regarding a specific area may be considered together and that the accurate weighing or comparison of it so that sound judgements can be made"* (Tomlinson, 1962, p. 1-2).

This early work created the first computerised geographic information system through the Canada Land Inventory (Tomlinson, 1967, 1968) and coined the now globally known term; Geographic Information System (GIS). The major function of the GIS, at that time using punch-card data entry, was a digital methodology to measure and summarise geographical areas of specific characteristics, demonstrating the various capabilities for spatial data manipulation and analysis to answer many queries of a geographical nature (Goodchild, 1985) using various environmental, cultural, and economic variables. Tomlinson is thought of as the father of GIS through his role in persuading the Canadian Government that the creation of the Canada Geographic Information System (or CGIS, as it became known) in 1966 was a worthwhile investment (Coppock and Rhind, 1991). Interestingly, the first use of the phrase 'geographic information system', but not the acronym GIS, is in a technical report by Dacey and Marble (1965), observing that *"the primary function of a geographic information system is to make spatially oriented information available in a useable form"* and that *"the domain of a geographic information system is truly two-dimensional, and it is necessary to compute, interpret, describe and analyse within this two-dimensional structure."*

In the United States, the academic research community, through urban planners, geographers, cartographers, mathematicians, and computer scientists, were also exploring thematic mapping, spatial analysis and 'information systems' for urban and environmental planning. At the University of Washington, Edgar Horwood explored the application of computers for urban planning in 1960, specifically to map land-use activity around interstate intersections to study pressures on zoning. This

research also created a need for the analysis and mapping of US Census data and the creation of a parcel-level database. In August 1963, Horwood, whom later established the Urban and Regional Information Systems Association (URISA) in 1966 and was its first president, organised the ‘First Annual Conference on Urban Planning Information Systems and Programs’ at the University of Southern California to share information on development in regional information systems (URISA, 2016).

Howard Fisher, a Chicago architect, attended a workshop on computer mapping on urban planning and civil engineering offered by Horwood, also in 1963. Inspired by these computer possibilities, Fisher immediately began work on an automated cartography computer mapping system himself (SYMAP – Synagraphic Mapping; a vector model for computer generated maps) at the North Western Technical Institute. In December 1965, and after making unsuccessful approaches to Chicago and Northwestern Universities, Fisher established the Harvard Laboratory for Computer Graphics (title lengthened by the addition of ‘and Spatial Analysis’ in 1968) in the Graduate School of Design at Harvard University (where he originally studied), with a Ford Foundation seed grant (Coppock and Rhind, 1991). Fisher’s 1965 proposal to the Ford Foundation emphasised gathering factual information about urban planning. While ‘environmental’ aspects hardly appeared in the initial proposal, by 1967, with issues of environmental planning increasing in prominence, the Graduate School of Design had gathered several students to compare techniques used for environmental analysis and design. From these initial efforts a major regional study was conducted for the Delmarva Peninsula in the USA, a project pivotal to understanding early GIS (Chrisman, 2006).

While the Harvard Laboratory was founded with SYMAP as a core project, for 25 years it continued to develop pioneering computerised mapping and geospatial analysis programs, such as SYMVU (3D perspective views of SYMAP), CALFORM (choropleth mapping), POLYVRT (to topologically structure data), GRID (display of raster cells using SYMAP output techniques), and ODYSSEY (an extension of POLYVRT with a more efficient polygon overlay algorithm and vector-based GIS system of processors to manage large geographic files and containing many functions of a modern GIS), that were produced by some of the smartest people working in computer programming, geography, cartography, and other disciplines (Chrisman, 2006). With over 40 employees at its peak, the Laboratory staff included the likes of former Lab director Allan Schmidt, Graphic Systems president Eric Teicholz, renowned GIS academic Dr. Nick Chrisman, Esri director of software development Scott Morehouse, and Esri president Jack Dangermond, among others.

With the hindsight of working in the geospatial sector for more than 40 years, the researcher would argue that the Harvard Laboratory for Computer Graphics and Spatial Analysis provided the pivotal foundation and visionary environment for planners, geographers, cartographers, mathematicians, computer scientists, artists, and many others to converge and rethink thematic mapping, spatial analysis, and to progress in earnest what is now called GIS (Chrisman, 2006). By way of example, it is worth reciting a ‘view of the future’ from Allan Schmidt, whom was Executive Director

of the Lab from 1971 to 1981, overseeing a period of great productivity in research and outreach. In 1979, 40 years ago, projecting into the future, he observed:

“Personal uses of computing will undoubtedly include the ability to generate computer maps using a new technology known as Mapavision. Mundane applications will include preparation of route maps at home or en-route for the journey to work, play, shopping, picking up the kids, etc., taking into account existing traffic conditions and a minimum travel path (especially for those families with many children!). Shopping for a particular product will be facilitated by preparation of a map showing the locations of all stores having that product in stock. Vacation trips can be planned and updated during the trip to take into account weather, road conditions, changing interests of the travellers (including those kids), and accommodations available. Cross country travellers will have the novel opportunity of not being able to get lost due to the constant availability of a map on their TV screen which pinpoints their current location. Of greatest importance, however, will be everyone’s ability and right as a free citizen to display information related to recent and forthcoming public policy issues on the national, regional, and local level....” and *“the medium of computer graphics may prove to be the messenger (if not the message) by which all people will most effectively benefit from the emergence of computer technology.”* (Chrisman, 2006). A simple, yet incredible, vision at that time given that it has now been realised.

Dangermond, a landscape architect, joined the Harvard Lab in 1967 to complete a master’s degree and aided in developing SYMAP. At the time, Harvard had only one supercomputer, and Dangermond had to assemble unwieldy stacks of punch cards for processing. Finding processing times faster at night, Dangermond succeeded in printing his first computer map after a month of night work (Waldheim, 2011). After completing his master’s and moving back to California, Dangermond founded the Environmental Systems Research Institute (ESRI) in 1969 as a non-profit organisation engaged in the field of environment and land use analysis projects, initially using and developing the cell-based GRID package. The early mission of ESRI focused on the principles of organising and analysing geographic information (Kemp, 2008). After moving to a for-profit model, and with Morehouse joining as the main software architect and designer for ARC/INFO (ESRI’s first GIS software package), and its subsequent launch in 1982 (Coppock and Rhind, 1991), the evolution of the ESRI suite of GIS tools has steadily grown and dominated so much over the past thirty years to now be the unequalled leading GIS solutions provider on the global market.

In the United Kingdom the Experimental Cartography Unit (ECU), a research unit of Britain’s Natural Environment Research Council (NERC), was founded in 1967 by David P. Bickmore, head of the cartography unit at the Clarendon Press. Like the Harvard Laboratory, the ECU stimulated and championed the possibilities of computer-based mapping, to advance the art, science, technology and practice of making maps by computers (Kemp, 2008). In the late 1950’s, Bickmore’s work on the manually produced *Atlas of Britain* while at Clarendon Press led him to the conclusion that the computer

was needed if a cost-effective national atlas was ever to be produced. Bickmore eventually convinced the NERC to establish a new research unit to ‘experiment in both computerised methods of construction and the graphic design of maps’ (Inyang and Daniels, 2009). Rhind (1988) provides a detailed history of the ECU which, driven by the vision and ambition of Bickmore, pioneered numerous developments in cartography and GIS that we now take for granted. Yet it rarely stands out in GIS histories, partly because it did not operate in the United States and partly because of the attitude of its founder toward the publishing of results (Kemp, 2008). A key success of the ECU was providing the incentive for the British Ordnance Survey to move into automated, computer-based mapping of their large-scale products (1:1250 and 1:2500), and subsequent derived and generalised products at 1:10,000 scale. Indeed, a 1971 publication showed generalised maps produced at 1:250,000 scale from the 1:2500 originals. This led the Ordnance Survey to set up what was probably the first digitizing production line in the world in 1973 (Kemp, 2008).

3.3 Geospatial Technology Evolution

Following on from the early work of the pioneers, the 1970s and early 1980s provided the technology evolution of geospatial information. The early 1970s saw the emerging computer mapping automate map drafting in a radical shift from analogue inked lines on paper to digital values stored on disk (Berry, 2013). During this period, the creation of digital representations and ‘overlays’ of existing paper maps and the development of main-frame digital computer mapping and cartography software began in earnest, primarily through research institutions and specific large government agencies such as the US Census Bureau (Foresman, 1998; Chrisman, 2006).

In 1970 the US Census Bureau produced the first geocoded national census. The topological structure of street segments was coded by identifying the IDs of right and left blocks and “from” and “to” nodes. Also recorded, using X,Y coordinates, were the address ranges of street segments. These files were known as DIME (dual independent map encoding) files and were the forerunner of the US Census Bureau’s more sophisticated TIGER (topologically integrated geographic encoding and referencing) files (Mark et al., 1997). With its development taking almost 10 years and with no room for failure, the TIGER database, the first nationwide digital map of roads, boundaries and water, was initially created for the 1990 US Census in an effort to modernise the once-a-decade head count. However, its impact has extended well beyond its initial purpose by offering common map data in electronic form that powers today’s GIS industry. Today, as a national digital map database, TIGER contains all geographic features – such as roads, railroads, rivers, and legal and statistical geographic boundaries – needed to support the Census Bureau’s data collection and dissemination programs, are updated annually, and available for free download (Tim Trainor, Chief Geographer, US Census Bureau, personal communications, April-May, 2018).

A key milestone in the satellite technology evolution occurred on 23 July 1972 with the launch of the first Landsat spacecraft. Then known as the Earth Resources Technology Satellite, this was the first dedicated satellite launched to study the Earth's land masses. In 1975, the name was changed to Landsat (Short et al., 1976). Launched in July 1982, the fourth-generation satellite, Landsat 4, was able to capture a wider (and more scientifically-tailored) portion of the electromagnetic spectrum and could see the ground in greater detail through a new instrument, known as the Thematic Mapper (TM) (Pino, 2008). It had the primary goal of providing a global archive of satellite imagery coverage, which greatly helped the worldwide thematic mapping applications being developed at that time, and later visualisation solutions including NASA World Wind, and then Google Earth. Since 1972, the Landsat program has been continuously and systematically monitoring changes in the Earth; its archive representing the longest and continuous space-based record of changes on the Earth's surface (Williams et al., 2006).

3.4 Geospatial Adoption and Commercialisation

The 1980s were characterised by an increasing and accelerating trend towards acceptance of GIS concepts and strong competition among vendors. The science of GIS, in both theory and practice, was advanced significantly through the works of leaders like Burrough (1986) where the first principles of raster and vector data structures were described, and digital elevation models (DEMs), spatial interpolation, and raster analysis were introduced. Complementing these innovations and knowledge, the development of GIS technology and software exploded. Esri developed ARC/INFO – the first commercial GIS product, released in 1982 and began their evolution into arguably the world's leading GIS software company. In 1986 MapInfo developed inexpensive PC-based mapping software as an alternative solution to Esri, and with a focus on demographic data solutions. While in 1987, Clark University geography professor J. Ronald Eastman developed IDRISI, as a blend of GIS with remote sensing capabilities for the analysis of geospatial data. Also in 1986, the first French earth land resources satellite, SPOT (originating from the French 'Satellites Pour l'Observation de la Terre') was launched. With the primary mission of obtaining Earth imagery for land-use, agriculture, forestry, geology, cartography, regional planning, water resources and GIS applications, SPOT provided complete coverage of the Earth every 26 days at initial resolutions of 10m, and enhanced to 2.5m over time as subsequent satellites were launched (Disabato, 2010). It was the first globally distributed commercial satellite imagery.

With new developments in compute power that were capable of handling larger amounts of data, this period also represented a migration of geospatial information technology to more affordable integrated graphics workstations, client-server environments and spatial database management systems, which in turn facilitated the sharing of data across 'networks' (NGAC, 2009) through Transmission Control Protocol and Internet Protocol (TCP/IP). Established in the mid-1980s, TCP/IP provided

researchers with the means to assemble the “network of networks” that became the modern Internet (Gilbert, 1995). The online world then took on a more recognisable form in 1990 when Berners-Lee (1989) invented the World Wide Web, a paradigm shift that provided a common means of accessing data online in the form of websites and hyperlinks.

3.5 Geospatial Standardisation and Usability

Despite some criticism from social and human geography purists (Schuurman, 2000) the 1990s saw mass adoption of geospatial information and a maturation of spatial analysis and modelling for decision-making (Berry, 2013). The terms ‘Geographic Information Science’ and ‘Geomatics’ also emerged in the early 1990s in response to concerns that geographic information systems were perceived as being theory-poor. Yet, in the long term, the success of GIS would require strong theoretical underpinnings regardless. Led by Goodchild (1990, 1992), Geographic Information Science was quickly adopted as a popular term in academia, as it promoted scientific endeavours beyond just technological GIS applications (Onsrud and Kuhn, 2016).

At the same time, the Internet became a primary conduit by which to access and utilise standard maps, as GIS vendors encouraged organisations to add and share datasets to the map sets they were already making available (across the Internet) through easy-to-use graphical user interfaces (GUIs) and web portals. With the emergence of Web 2.0, and the emphasis on user-generated content and a participatory culture, ordinary citizens began to produce and share geospatial content on the Internet (Budhathoki, et al., 2008). These same opportunities provided new ways for governments and countries to consider coordinating ready access to geospatial information through the concept of Spatial Data Infrastructures (SDIs) as a practical means to overcome important barriers to effective data sharing and utilisation (Waters, 2017).

While the first iterations of SDI development emerged in the mid-1980s, designed to promote economic development through supporting the objectives of governments and supporting environmental sustainability (Masser, 1998, 1999), they took a substantial step forward in the early 1990s when the United States Office of Management and Budget (OMB) established an interagency Federal Geographic Data Committee (FGDC) to coordinate the “*development, use, sharing, and dissemination of surveying, mapping, and related spatial data*” (Masser, 2005a). OMB Circular A16 of 1992 defined the SDI “*as the technology, policies, standards, human resources and related activities to acquire, process, distribute, use, maintain and preserve spatial data*” (OMB, 1992, revised 2002).

Other early innovators and adopters (Masser, 1998, 1999, 2005a; Masser et al., 2008; Williamson et al., 2003; GSDI, 2004a) provided similar definitions that generally reflected SDIs and National Spatial Data Infrastructures (NSDIs) as being coordinated actions of nations and organisations that promote the awareness and implementation of complimentary policies, common standards and institutional arrangements for the development and availability of interoperable digital geographic data

and technologies to support decision making at all scales for multiple purposes. In the early 1990s, the initial capital investment required for producing digital information was still high, and the Internet and the Web were in their infancy. Therefore, large National Mapping Agencies continued to enjoy the economies of scale of production with the development of SDIs (Benkler, 2006; Budhathoki, et al., 2008). One of the greatest virtues of SDIs are their ability to facilitate and promote geospatial data sharing throughout all levels of government, academia, the private sector, civil society, and the general community, thus enabling the effective use of geospatial information for sustainable national development and a multitude of every day map and location-based requirements (Groot and McLaughlin, 2000; Masser, 2005b; Crompvoets and Bregt, 2007).

While discussed in more detail in Section 3.7, the proposal for, and development of, the Infrastructure for Spatial Information in the European Community (INSPIRE) Directive by the European Commission in the early 2000's exemplified the virtues of SDI's as a means to facilitate and promote geospatial data sharing (Vancauwenberghe and van Loenen, 2018). The Directive was adopted in May 2007 and was a major milestone for mapping agencies in Europe (European Union, 2007). Such SDI concepts validated the essential role geospatial information could play in modern society, and still apply today in an effort to ensure that as much publicly collected geospatial information as possible is made widely accessible and available in a timely manner and at minimum cost (van Loenen and Grothe, 2014). However, as Crompvoets et al. (2004) and Dessers et al. (2013) observe, SDIs are a complex concept with many facets, their effectiveness often depending on the uptake of geospatial data use and sharing by organisations in support of their business processes. Section 3.6 details the strengths and weaknesses of SDIs as enabling national information architectures and platforms that can also be applied to sustainable development challenges.

In an effort to take advantage of the new wave of technological innovation leading into the 21st century, in January 1998 Al Gore, Vice President of the United States, proposed the need for a 'Digital Earth' – a multi-resolution three-dimensional representation of the planet, into which we can embed vast quantities of geo-referenced data to understand information about our society and our planet, including decision-making for a sustainable future, land-use planning, agricultural, and crisis management, and to collaborate on the long-term environmental challenges we face (Gore, 1998).

The removal of selective availability for the high-quality positioning and timing Global Positioning System (GPS) signal by the US Department of Defense in 2000 (White House, 2000) disrupted the traditional 'static' data positioning norms (and the accepted error margins) and paved the way for new 'dynamic' global positioning innovations such as in-car navigation systems and a multitude of location-based services and applications via mobile devices that we now take for granted as if they have always been there.

A major benefactor of the aforementioned high-quality GPS positioning, combined with mobile phones as the primary computing device for billions of people, especially in developing countries, was the volunteered geographic information (VGI) movement. The most well-known example is OpenStreetMap (OSM), which was established in 2004 to encourage the growth, development and distribution of free geospatial data and provide it for any citizen to use and share (OSM, 2019). OSM is now a free, open-access VGI platform to which volunteers from all over the world collaboratively contribute data into an editable map of the world that is released with an open-content license (OSM, 2019). Today, OSM is a mainstream data capture and information source used in developing countries, particularly for humanitarian aid and disaster response. Consequently, this same VGI influence is challenging the role of SDIs in terms of being able to accommodate VGI and derive greater utility from their combined synergy (Budhathoki et al., 2008).

3.6 Digital Transformation

The rapid onset and mainstreaming of digital technologies to enhance and transform governments and businesses has given rise to a new disruptive and agile technology environment since the mid-2000s. This fifth phase represents the ‘digital transformation’ towards mass consumerism of geospatial information and location-based services. By way of example, perhaps the biggest disruptive paradigm shift for the global geospatial sector, particularly for public realisation of the value and consumption of location-based data, was the launch of Google Earth in June 2005. Combining geospatial data and processing to create content, then packaged it in an easily consumable format that could be accessed from a web-browser on virtually any computing device, Google offered for the first time a consistent visualisation experience for everyone – and all for free (NGAC, 2009). This enabled geospatial literacy to be rapidly introduced to the global community; literally using Google Earth and Google Maps for obtaining answers to location-based questions that had formerly not been imaginable. More importantly, it changed the way that people understood geography and defined geographic areas, and ‘mainstreamed’ geospatial information and the multitude of resultant consumer location-based applications that are readily available today (NGAC, 2009). It also significantly motivated the geospatial industry to be more innovative and to embrace an emerging information economy and the ‘digital transformation’ opportunities that we have today; where the expectations for growing global interconnectivity and information societies are being underpinned by both digital disruption and digital transformation – enabling e-commerce and a modern information economy to prosper.

Technological enablers such as the Internet, Cloud computing, analytics, Big Data, mobile devices, unmanned aerial systems, and the rapid explosion of location-based services, which bring everyone directly into contact with location information every day, have ensured that people the world over, are beginning to appreciate the need for geospatial information in their consumption of data (UN-GGIM, 2013a, 2015b). As a result, a large proportion of the global community now have an entirely

different set of geospatial information uses, needs and expectations than they did even ten years ago, such has been the evolutionary change. In some respects, it also indicates that geospatial information and services are now being driven more and more by users and consumers in response to their contemporary needs as much as responding to technology developments and breakthroughs. Both of these trends are gaining pace as technology creates new experiences and expectations, which in turn creates new opportunities but also seismic shifts in consumer behaviour and expectations (Auerbach, 2018).

So great is this impact, Schwab (2016) argues that digital transformation and ‘disruptive technologies’ have now emerged and are affecting our lives in ways that indicate we are at the beginning of a Fourth Industrial Revolution; a new era that builds and extends the impact of digitisation in new and unanticipated ways. Technology is transforming almost every aspect of our lives, and all sectors of industry and the economy at an unprecedented pace and scale and is similarly having a major impact on the geospatial industry, creating innovative technological enablers and applications, and generating previously unimaginable amounts of location-referenced information. These technologies and processes are not only disruptive, but they are continually evolving, providing new opportunities for innovation and enabling business, industry and governments to be more agile, to adapt and transform their own internal processes, and to scale-up capability more quickly than in the past.

In the same vein, increases in the amount and variability of data, combined with rapid advances in digital and communications technologies, have provided the opportunity for geospatial information to be leveraged as a transformative capability for governments to formulate better policy and to respond to national priorities. The huge growth in the generation of data has meant that governments now realise the value of digital technologies and data as key strategic assets that lead to valuable and quantifiable results, thus changing the lives of economies and societies around the globe. Yet, reaping the full benefits of the opportunities linked to the value and use of data and technology requires that they are embedded as core components of continuous efforts to modernise and digitalise public sectors, and that they support new ways of working and creating public value (OECD, 2018a). However, all institutions, mechanisms and models are struggling to respond effectively to the pace of change and its distributed nature. New collaborative efforts are emerging across the world – processes that aim to build on both traditional strengths of host institutions but also draw in the expertise of other sectors – whether that be business, governments, civil society or academia (OECD, 2018a).

The downside of digital transformation and the technology innovation trend is that the lack of robust digital infrastructure, including Internet connectivity and Information and Communication Technologies (ICT) infrastructure, are still major limiting factors to the proliferation of digital, location-enabled services and business models in developing countries. While many countries have made significant progress in building digital infrastructure with improved coverage and quality in the recent past, most of the developing economies are found to be lagging in this front. The absence of this

fundamental prerequisite, known as the ‘digital divide’ limits the stakeholder’s ability to capitalise on many of the basic utilities of the geospatial industry (Geospatial Media, 2018). The implications of the digital divide and the ‘geospatial digital divide’ are discussed in detail in Chapter 5 of this dissertation. While there are many emerging technologies and terms associated with digital transformation, it is Big Data and the Cloud that are the two dominant technologies driving and accelerating the geospatial industry and capabilities. These are followed by artificial intelligence (AI) and the Internet of things (IoT). Ironically, all are heavily dependent on wireless and broadband internet applications as the backbone of the digital ecosystem. Realising the impact of digital transformation, and its impact on empowering citizens in developing countries, requires the necessary infrastructure to bridge the digital divide (Geospatial Media, 2018).

3.7 SDIs as Enabling National to Regional Information Architectures

As described briefly in Section 3.5, the first iterations of SDI development emerged in the mid-1980s, primarily through large organisations, such as National Mapping Agencies, which had the financial resources, economies of scale, and mandates to meet national geospatial information needs (Goodchild, et al., 2007). As a long-standing and well understood enabling infrastructure to theoretically provide the ‘institutionally’ coordinated policies, common standards, arrangements, and effective mechanisms for the development and availability of interoperable geospatial information at multiple levels of governments, it would be remiss not to delve into the virtues of SDIs in more detail within the context of this Chapter, this dissertation, sustainable development, and as a means to address contemporary geospatial information and related policy challenges. These virtues have direct relevance to the development of the strategic framework in later Chapters.

In order to improve access, sharing and integration of geospatial information and services for evidence-based decision-making, SDIs over the past twenty years have constantly evolved and emerged as ‘the’ geospatial information platform that could also be applied to sustainable development implementation challenges (Hennig and Belgiu, 2012). Early SDI initiatives focussed on data, accessibility, and services, the core components being policy, access network, technical standards, people (including partnerships) and data (Figure 3.2). These soon led to the development of, firstly product-based SDI approaches, where models tended to be data producer and national mapping agency led, focusing on data production, database creation, and centralisation; and then process-based SDI approaches, driven more by data sharing and re-using data collected by a wide range of agencies for a great diversity of purposes. (Figure 3.3) (Rajabifard et al., 2002; Rajabifard et al, 2003).

Throughout the 2000s, this conceptualisation of ‘first generation’ product-based SDIs began to shift more towards a user-oriented approach, where the focus continued to move towards the management of data, or a ‘second generation’ process-based continuum approach (Rajabifard et al., 2006). Figure 3.4 shows the SDI continuum through the development of the first and second generations

of SDIs, the change from a product to process based model, and the changing role that national government, sub-national government and the private sector play, with an indication of the different groups of countries developing SDIs also shown (Rajabifard et al, 2006). Most countries, from developed to developing, were at some stage of the continuum towards maturity, as illustrated in Figure 3.4. At that time, moving towards the next generation translated into the future focus for spatial information, including the delivery of a virtual world to enable decision-making at a community level within a national context (Rajabifard et al, 2006). In the same period of time, the virtues of SDIs in the provision of their data and services were being considered regionally in Europe through INSPIRE, and in the areas of poverty reduction, economic, and sustainable development.

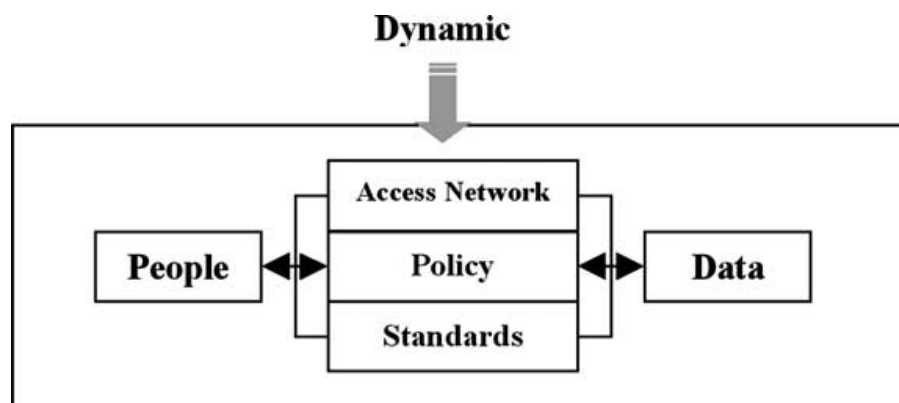


Figure 3.2: The nature and relations between SDI components (Rajabifard et al, 2002).

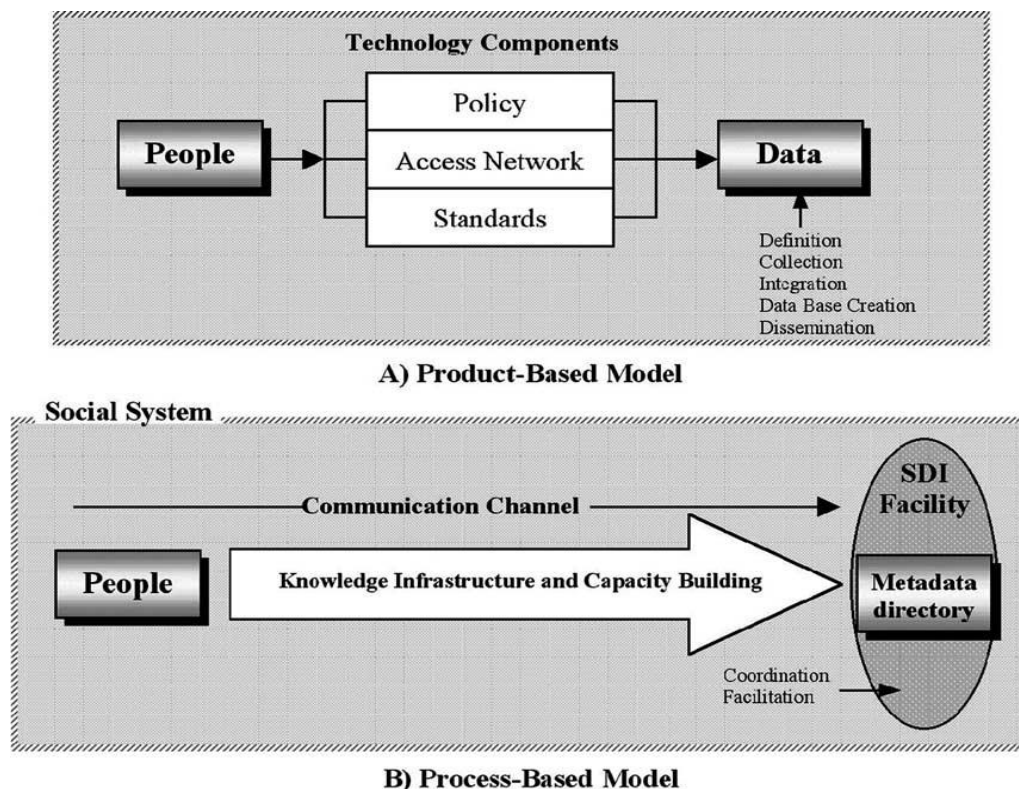


Figure 3.3: (A) Product-based model; and (B) Process-based model (Rajabifard et al, 2002).

Feeney et al. (2001) reasoned that addressing the multiple issues concerning sustainable development creates a growing need to organise data across disciplines and organisations through the development of SDIs to support decision-making. The principle objective for developing SDIs is to achieve better outcomes from geospatially related economic, social and environmental decision-making. Further, the design of any SDI requires understanding the nature of the concept, the contributing components, the impact of global drivers and the needs of the user community. Crompvoets et al. (2004) and Masser (2005b) established in the early 2000s that more than half of the world's countries claimed some form of SDI development, but that the reported levels of implementation and maturity, including the various policy options and institutional structures, were both questionable and not able to be confirmed.

Engagement in SDI development does not necessarily translate into a fully operational SDI over time. Masser (2005c) also noted that the evolution of SDIs is a long-term task and that their 'adoption and implementation' often reflect the extent to which (government) organisations reinvent themselves in response to changing political, institutional and technological circumstances. Because of their dynamic and complex nature, SDIs remained a fuzzy concept to many, and depending on their needs and circumstances, practitioners, researchers, and governments adopt different views of them (Williamson et al., 2003).

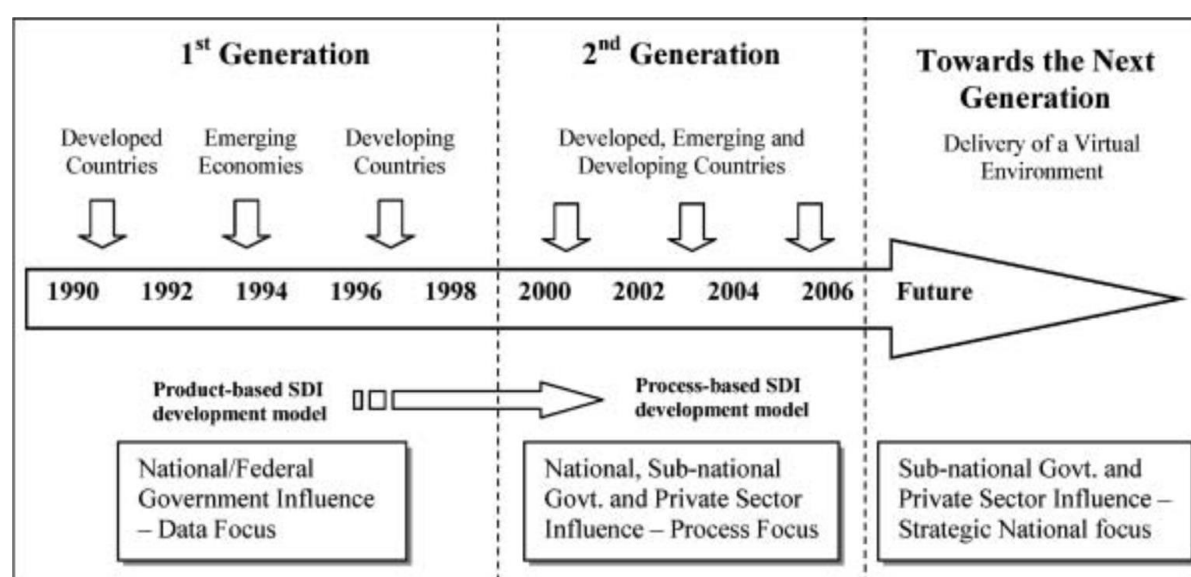


Figure 3.4: Continuum of SDI Development based on the first and second generations of SDI (Rajabifard et al, 2006).

By 2010 the recognition that countries should develop and implement policies for the efficient and coordinated management of their spatial data and services had become almost universal, with SDIs at the national, regional and global levels evolving with increasing resolve and commitment. However, although they were an increasingly important element of the infrastructure that supports national to

regional economic development, environmental management, and social stability there were still inherent policy and institutional limitations that existed in developing such platforms and infrastructures. One of the weaknesses being that many SDIs were still predominately supply, rather than demand, driven and are rarely designed to respond directly to high priority societal policy issues (Taylor, 2010).

Therefore, the ‘third generation’ has quickly evolved as SDI needs transitioned away from a wholly national government data ‘supply’ to a non-government data ‘demand’ driven approach – towards a more user-centric SDI, where the development of SDI concepts are driven by users, including citizens, and their requirements. This has had placed particular emphasis on SDI users and their needs being at the center of each SDI initiative, and their requirements essentially determining the nature of the SDI and its core components (Hennig and Belgiu, 2012). By extension, the user-centric approach is now recognizing that synergies between SDIs and VGI has a greater potential to lead to a third generation SDI in the development continuum proposed by Rajabifard, et al (2006) in Figure 3.4 (Budhathoki et al., 2008). More recently, concepts such as ‘open’ SDIs are evolving. While primarily dealing with open geospatial data, and making these data freely available to citizens, businesses and other users for re-use without restrictions, it enables the SDI to support the delivery of e-services to citizens, businesses and other stakeholders, a higher degree of transparency and inclusiveness (Vancauwenberghe and van Loenen, 2018; Brovelli et al., 2019).

To more effectively respond to the issue of sustainable development a very clear definition of the problem and the design of an integrated infrastructure to address that problem at the national, regional or global scale is required. In many cases, the SDI community assumes that the infrastructure being created will provide the information to respond to any situation simply by the provision of comprehensive data layers at the appropriate scale (Taylor, 2010). This often leads to a serious ‘disconnect’ between national needs for the management of geospatial information and current SDI approaches. Comprehensive data layers have value in their own right but a more targeted approach is of greater utility to decision-makers (Taylor, 2010). In addition, many SDIs do not include adequate socio-economic data, yet these data are critical if SDIs are to act as integrating infrastructures to meet the needs of sustainable development (UN-GGIM, 2012a).

Addressing strategic geospatial issues at a United Nations meeting, Scott (2009a), reflected that interoperability is a growing trend and key for further successful development and application of geospatial data. However, the SDI community has to work together to remove barriers, not only through standardisation efforts, but also through institutional and legal systems so that they can meet challenges presented by the ever changing and evolving needs of the day. There is no doubt that geospatial technologies are now reaching a stage of advancement and maturity so that the remaining policy and governance issues and challenges can be confronted head on to enable the information to be leveraged, integrated and delivered appropriately, and in a timely manner. The message and motivation are

consistent across many forums, that it is not just about an ‘SDI’, but how geospatial information and related technologies are applied to the contemporary problems facing the world (Scott, 2009a).

Onsrud and Rajabifard (2013) suggest that the applications and utility of SDIs are continually evolving, as the technical constructs continue to develop, leveraging the latest ICT developments to better support its users and deliver improved outcomes, including new technologies such as Cloud computing and data mining. However, the greatest challenge that continues to impede the success of SDIs, and any geospatial enablement, continues to rest not on the technical aspects, but on the ability of people to continue to reach across organisational and administrative divides to nurture an environment that supports information sharing to achieve better outcomes for governments, the country and the community. Therefore, despite advances in technology, some of the strategic considerations that underpin SDI development continue to remain consistent. There is still much work that can be done to support and advance knowledge in these areas (Onsrud and Rajabifard, 2013).

For many national governments, where much of the policy emphasis is placed on providing accurate, timely and reliable data to support decision-making, there are still significant impediments to providing sustainable information infrastructures for both accessing mapping data and translating it into information for decisions (UN-GGIM, 2012a; Berry, 2013). The challenge of coordinating and sharing standardised and fit-for-purpose geospatial information has proven elusive in both concept and practice for many national governments, agencies and decision-makers around the world. This is especially so in the least-developed and developing countries where governments continue to face problems of poor data quality, lack of timely data, and a lack of interoperability between different sources of data. This may result in governments using, and then relying on, inaccurate or low-quality data on which to base their decisions (UN-GGIM, 2015a).

For example, while geospatial information is increasingly being used in Africa and other developing regions, many countries are frustrated by limited access to data and the absence of tools to allow for analysis and visualisation. Innovative and low-cost geospatial approaches are being applied to improve the timeliness, availability, and use of data for monitoring of progress towards sustainable development, but more capacity building will be needed to scale up existing initiatives and to bring innovative applications from other parts of the world to areas such as Africa (GSDR, 2015). The lack of consistent up-to-date base mapping – fundamental geographic datasets such as geodetic control, elevation, drainage, transport, land cover, geographic names, land tenure, etc. – across Africa remains a challenge, although individual countries are making some progress (GSDR, 2015).

While Africa continues to have unique challenges (discussed further in Chapter 8), there have been a number of attempts to provide both guidance and guidelines on the implementation of SDIs in developing countries and the African continent. The ‘SDI Cookbook’ (GSDI, 2004a) and ‘SDI Africa: An Implementation Guide’ (GSDI, 2004b) in particular, made attempts to progress the value

proposition of SDIs and NSDIs for countries in Africa, and to offset the many challenges with new opportunities in both geospatial data and policy.

Despite these efforts, the utilisation of geospatial information and associated SDI implementation in Africa remains an ongoing challenge – one which is quite unique, but homogeneous to the region. Factors include: an ongoing and pervasive lack of awareness and leadership by high level policy and decision-makers; low availability of fundamental geospatial data; a lack of access, availability and interoperability among the datasets that are available; and a lack of the necessary skills and resources to leverage the use and dissemination of geospatial information (Eelderink et al., 2008). Most importantly, there are no regional or national strategies and structures in place to build the appropriate implementing foundation.

As observed by the Chair of UN-GGIM Africa, Mr. Sultan Mohammed Alya, in April 2018, *“African countries are lagging behind, thus widening the ‘Geospatial Digital Divide’. The main reason for the failure to date is believed to be the approach considered in the previous studies, which focused mainly on a bottom-up approach with geospatial information organisations and professionals attempting to take the lead in NSDI implementation. This has created, to a large extent, a situation of geospatial organisations and professionals talking to themselves, rather than involving the high level decision-making political organs of government from the start.”*

While a number of comparative assessments have been made (Maphale, 2019), one of the mechanisms to establish a more coordinated African position, structure and strategy was the development and publication by the United Nations Economic Commission for Africa (UNECA) and the Regional Committee of UN-GGIM for Africa, of an African Action Plan on geospatial information. Entitled ‘Geospatial Information for Sustainable Development in Africa: African Action Plan on Global Geospatial Information Management – 2016-2030’ (UNECA, 2017), the Action Plan is discussed in detail in Chapter 8, Section 8.3.3.

Conversely, in Europe the INSPIRE Directive is a very structured and defined legislative framework which aims to create a European Union SDI for the purposes of ensuring that geospatial information is able to be more accessible and interoperable to support primary environmental policies and policy-making, including sustainable development, across Europe. Entered into force in May 2007 by the European Union after six years of preparation, INSPIRE provides an SDI framework based on the infrastructures for spatial information established and operated by the Member States of the European Union for 34 spatial data themes, and are compatible and shared according to common implementing rules that are supplemented with measures at the community level (European Union, 2007).

Paragraph 5 of the Preamble states that INSPIRE *“should be based on the infrastructures for spatial information that are created by the Member States and that are made compatible with common*

implementing rules and are supplemented with measures at Community level. These measures should ensure that the infrastructures for spatial information created by the Member States are compatible and usable in a Community and transboundary context” (European Union, 2007). This suggests that national SDI implementations must be compatible with INSPIRE, but also free to stand alone within existing national circumstances.

The Directive required Member States to comply with its laws, regulations and administrative provisions by May 2009, and to report to the European Commission every three years, commencing May 2010, on how they are implementing INSPIRE, including the costs and benefits of implementing the Directive (European Union, 2007, Article 21). In May 2014, the Commission was required to present to the European Parliament a (mid-term evaluation) report on the implementation of INSPIRE based, inter alia, on reports from Member States in accordance with Article 21 (European Union, 2007, Article 23). Full operational implementation of INSPIRE is expected to be presented to the European Parliament by the end of 2021.

With regard to the implementation of INSPIRE, evidence presented in the mid-term evaluation report (European Environment Agency, 2014) shows that, for many measures, it is inconsistent. While considerable progress had been made, implementation was still insufficient, and adjustments were needed. Barriers to data sharing continued to exist, and most of the measures to ensure interoperability were yet to be implemented. The outcome of the public consultation indicated that these strands of INSPIRE were considered to be highly technically complex and required more support. Some steps had been taken to overcome policy, organisational, legal and cultural barriers amongst participating countries, although much still needed to be done. Finally, the coordination action required strengthening at European Union, national and local levels, and across borders (European Environment Agency, 2014).

In summary, INSPIRE was seen as a complex approach. *“The main obstacles to the implementation of INSPIRE that emerge from the evaluation are the general technical complexity and the communication and coordination of the implementation of the Directive. Possible measures suggested to adjust the objectives and actions in view of these issues could include a reduction in the administrative burden through simplified data sharing, awareness raising, capacity building and training for those public sector officials involved and ongoing improvements in coordination and communication amongst and between different countries”* (European Environment Agency, 2014, p. 6). Although the SDI building initiatives (of INSPIRE) use European and similar international technologies and standards, their diverse peculiarities reflect different traditions, cultures and socio-economic models, as well as the different ways in which geospatial data are managed in the particular countries (Craglia and Annoni, 2007; Masser and Cromptoets, 2015).

However, since the uptake on open data, and most notably after the enactment of European Union Directive 2019/1024 (European Union, 2019) on open data and the re-use of public sector information, many of the legal and financial burdens for data sharing are expected to disappear, particularly for high-value (geospatial) datasets. The identification of specific high-value datasets has been based on their potential to: (a) generate significant socioeconomic or environmental benefits and innovative services; (b) benefit a high number of users, in particular small to medium enterprises (SMEs); (c) assist in generating revenues; and (d) be combined with other datasets. Critically, these datasets are to be provided free of charge, compatible with open standard licenses, machine readable, through APIs, and with no restrictions in their reuse (European Union, 2019).

Today, as both digital disruption and digital transformation grow and gain mainstream momentum, the contrast between SDI development in Africa, as a developing region, and Europe, as a developed region, could not be starker. This contrast, which has existed for many years, provides an opportune time for reflection and resolving impediments moving forward. INSPIRE has been in a very structured and regulated ‘development’ phase across Europe now for some 12 years, and anchored by SDI principles, objectives, implementing rules, actions and technical complexities of the same era. But technology, the data ecosystem and related architectures have evolved and moved ahead at considerable pace. It could be argued that the INSPIRE architecture is rapidly becoming outdated, based on ICT-concepts of the 2000-2008 era, data specifications are too complicated resulting in a lack of use, too data-supply oriented, not very user-centric, not enough adoption in European institutions, and with an unclear future after 2021. These ‘heavy architecture’ impediments and limitations/frustrations are real lessons that the developing countries can learn from as a means to ‘leapfrog’ with more agile and lighter technology enablers.

That said, one of the main achievements of INSPIRE has been that it has garnered both considerable awareness and momentum of the strengths and benefits in sharing geospatial information among public authorities across Europe. As such this awareness, or lack of, is very relevant for Africa. However, it is not very relevant from an implementation perspective as the contexts are totally different and there is no strong body that exists to legally enforce SDI implementation at national levels.

Chapter 6, in presenting an integrated geospatial information systems framework, discusses the future SDI as an integrative information system that is able to provide both the enabling platform and connection point to other national information systems and to the SDGs.

3.8 Regional to Global Geospatial Information Processes and Mechanisms

While the previous sections in this Chapter discuss the evolution and development of GIS concepts, geospatial information and SDIs, and their understanding and uptake at the governmental and policy level, this section discusses the establishment of relevant regional to global geospatial information processes and intergovernmental mechanisms within the United Nations system, their

applicability to the SDGs, and the issues, challenges and impediments to geospatial information contributing more holistically to sustainable development.

As was detailed in Chapter 2, the mainstream theoretical framework and understanding of sustainable development evolved through international processes led predominantly by the United Nations. Since 1972, and due to its central role in global governance, the United Nations has been the driving force in global efforts to translate sustainable development ideas into policy and action for all Member States. What is not so known, and not previously documented in detail, is that the United Nations, through ECOSOC, has also played a historical role and driving force at an intergovernmental level in the development of mapping that stems back to the post second world war period. ECOSOC's contribution, initially with a regional emphasis on national surveying and mapping, then evolving with data and technology change to better understand and stimulate the development of emerging SDIs, and more recently globally in geospatial information management, has made a significant impact for many countries in breaking down barriers and impediments that existed – not just technical, but also institutional and organisational – in building and sustaining geospatial information infrastructures and capabilities to address national to global challenges (UN-GGIM, 2015a) A timeline of geospatial information development in the United Nations is presented in Figure 3.5.

3.8.1 United Nations Regional Cartographic Conferences (UNRCC)

At its sixth session in February 1948, ECOSOC adopted resolution 131(VI), recommending that governments of Member States stimulate surveying and mapping of their national territories and that the Secretary-General of the United Nations take appropriate action to further such efforts (United Nations, 1948, p. 653). This was in recognition that, while surveying and mapping of areas were primarily the responsibility of the governments of the countries concerned, it had been demonstrated that some problems were of international interest, and that close cooperation between nations was essential to improve cartographic work in the countries of the regions, as well as on development of important economic and social projects. A Committee of Experts on Cartography was appointed by the Secretary-General to study the problem and advise upon the means of its implementation (United Nations, 1948). The Committee, which met in March-April 1949, recommended convening 'Regional Cartographic Conferences' as an effective means to attain the objectives of resolution 131(VI). At its ninth session (in 1950) ECOSOC noted the report of the Committee of Experts on Cartography and requested the Secretary-General to consult with governments concerning the early calling of such Conferences.

These consultations indicated a wide measure of support and were able to be realised when the Government of India offered to host the first Conference for Asia and the Far East, to provide a meeting place, and to be responsible for all the physical arrangements for the Conference (UNSD, 2019). ECOSOC adopted resolution 556(XVIII) on 27 July 1954 and the First United Nations Regional Cartographic Conference (UNRCC) was held in the region of Asia and the Far East in February 1955

in Mussoorie, India (United Nations, 1955). The regional naming was changed from 'Asia and the Far East' to 'Asia and the Pacific' at the UNRCC's eighth meeting in January 1977 in Bangkok, Thailand. This name change was decided by resolution to align with the new title of the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) (United Nations, 1977, p. 27).⁴ The UNRCC for Asia and the Pacific (UNRCC-AP) was convened every three years as an effective means to attain its mandated objectives.

Following the establishment of UNECA,⁵ ECOSOC, at its thirty-first session in April 1961, adopted resolution 816 (XXXI) noting that the Governments of the Member States of UNECA, at their third session, expressed their desire that such a Regional Cartographic Conference should be convened, requested the Secretary-General, in cooperation with UNECA take the necessary steps to convene, not later than the end of 1962, a UNRCC for Africa (United Nations, 1961). The first United Nations Regional Cartographic Conference for Africa was convened from 1-13 July 1963 in Nairobi, Kenya, and sponsored by UNECA. It was clear to all present at the Conference that before Africa could begin to realise its vast potential for development, it will have to have accurate maps to identify and inventory its colossal resources. The making of these maps will require the broader possible application of the science of cartography (Pearcy, 1964). The Second UNRCC for Africa was convened in Tunis, Tunisia from 12-24 September 1966, but due to the financial challenges by Member States for travel, they were not able to be convened on a regular three-year rhythm. The Third UNRCC for Africa was convened Addis Ababa, Ethiopia from 30 October to 10 November 1972. The Fourth UNRCC for Africa was convened in Abidjan, Ivory Coast from 4-11 November 1979, followed by the Fifth meeting in Cairo, Egypt from 28 February to 7 March 1983, the Sixth meeting in Addis Ababa, Ethiopia in November 1986, the Seventh meeting in Ouagadougou, Burkina Faso from 6-11 September 1989, the Eighth meeting in Addis Ababa, Ethiopia from 22-27 February 1993, and the Ninth UNRCC for Africa was held at the new UN Conference Centre at the headquarters of UNECA in Addis Ababa, Ethiopia, from 11-15 November 1996 (UNECA, 1997).

Although the Ninth meeting resolved to request UNECA to convene the Tenth meeting in 1999 this was not to be, as the functions of the UNRCC for Africa would be subsumed by the planned Committee on Development Information (CODI) within the proposed reform of the intergovernmental machinery of the Economic Commission for Africa (UNECA, 1997). The meetings of the UNRCC for Africa were plagued by poor support from the Members States, with meetings being attended by an average of 21 countries. From the beginning the UNRCC for Africa called for African states to be better mapped, and for the establishment of their national mapping organisation, together with the need for capacity development (Derek Clarke, personal communications, March 2019).

⁴ The entire record of all UNRCC for Asia Pacific (UNRCC-AP) intergovernmental meetings is available here: <https://unstats.un.org/unsd/geoinfo/RCC/unrccapEvents.html>

⁵ The United Nations Economic Commission for Africa was established in 1958.

Taking note of the success of the UNRCC-AP since 1955, and recognising the need to hold similar Conferences in other regions, ECOSOC, at its fifty-sixth session in May 1974, adopted resolution 1839 (LVI) requesting the Secretary-General to make the necessary arrangements to convene the First United Nations Regional Cartographic Conference for the Americas (UNRCC-Americas) during the first quarter of 1976. The First UNRCC-Americas was hosted by Panama in March 1976 (United Nations, 1977) and operated on a four-year meeting rhythm.⁶

In order to take necessary intersessional actions on resolutions determined by the UNRCC's for Asia and the Pacific and the Americas (which only met every three and four years respectively), PCGIAP, and the Permanent Committee for the Infrastructure of Geospatial Data of the Americas (PC-IDEA) were established to undertake the technical work and operated under the purview of their respective Regional Cartographic Conferences (UN-GGIM, 2015a). PCGIAP was established pursuant to resolution 16 of the Thirteenth UNRCC-AP convened in Beijing, China in May 1994 (United Nations, 1994, p. 29). PCGIAP was established to address on an annual basis, and at a technical level through working groups, the urgent need for cooperation and exchange of experiences and technology on geographical information systems, including standards, infrastructure and institutional development – in other words, to better understand and stimulate the development of emerging SDIs. Even at that time, there was a strong expectation and understanding that ‘geographical information systems form a fundamental part of the information industry’ (United Nations, 1994).

Following the initiative of the UNRCC-AP, PC-IDEA was established just 3 years later, pursuant to resolution 3 of the Sixth UNRCC-Americas convened in New York in June 1997 (United Nations, 1997b, p. 18). In a similar vein, the objectives of PC-IDEA, to address on an annual basis, and at a technical level through working groups, replicated those of PCGIAP, but for the Americas region. However, PC-IDEA went a step further, with its mandate more explicitly aimed towards investigating and implementing SDIs in the region. The Sixth UNRCC-Americas, in making resolution 4: Spatial data infrastructure, called on all Member States in the Americas to consider establishing NSDIs; and that the United Nations encourage the proposed PC-IDEA to endeavour to link the Americas’ spatial data infrastructure into the Global Spatial Data Infrastructure. (United Nations, 1997b, p. 19).

In Africa, CODI, which replaced the UNRCC for Africa, was formally established in 1997 by the twenty-third meeting of the Conference of African Ministers of Finance, Planning, and Economic Development (UNECA, 2019a). The CODI was set up to provide policy and technical guidance for the sub-programme ‘harnessing information for development’ and comprised three Sub-committees, namely ICT, Statistics, and Geo-information (UNECA, 2010). CODI met five times, all in Addis Ababa, between 1999 and 2007 on a two-year rhythm, and with specific themes pertaining to information and

⁶ The entire record of all UNRCC for the Americas (UNRCC-A) intergovernmental meetings is available here: <https://unstats.un.org/unsd/geoinfo/RCC/unrccaEvents.html>

YEAR	TIMELINE: GEOSPATIAL INFORMATION DEVELOPMENT IN THE UNITED NATIONS
1927	World population reaches 2 billion.
1948	At its sixth session, ECOSOC adopts a resolution recommending that governments of Member States take action to stimulate surveying and mapping of their national territories.
1955	Following consultations, first United Nations Regional Cartographic Conference (UNRCC) for Asia and the Far East convened in Mussoorie, India.
1960	World population reaches 3 billion.
1963	Following establishment of UN Economic Commission for Africa (UNECA) and ECOSOC resolution, first UNRCC for Africa convened in Nairobi, Kenya.
1974	World population reaches 4 billion.
1976	Mandated by ECOSOC, first UNRCC for the Americas convened in Panama City, Panama.
1977	Following establishment of UN Economic and Social Commission for Asia-Pacific (UNESCAP), 8 th UNRCC for Asia and the Far East renamed to 'Asia and the Pacific' in Bangkok, Thailand.
1987	World population reaches 5 billion.
1994	Permanent Committee on GIS Infrastructure for Asia and the Pacific (PCGIAP) established by 13 th UNRCC for Asia and the Pacific in Beijing, China.
1996	Ninth and final UNRCC for Africa convened at UNECA in Addis Ababa, Ethiopia.
1997	Permanent Committee for the Infrastructure of Geospatial Data of the Americas (PC-IDEA) established by 6 th UNRCC for the Americas in New York, USA.
1997	Committee on Development Information (CODI) established by the 23 rd Conference of African Ministers of Finance, Planning, and Economic Development to replace the UNRCC for Africa.
1999	World population reaches 6 billion.
2000	UN Geographic Information Working Group (UNGIWG) established at UN in New York.
2005	UNGIWG initiates a process to establish a UN Spatial Data Infrastructure (UNSDI).
2009	CODI replaced by Committee on Development Information, Science and Technology (CODIST). First meeting at UNECA in Addis Ababa, Ethiopia.
2009	First Preparatory Meeting to establish UN-GGIM convened in Bangkok, Thailand.
2010	Second Preparatory Meeting to establish UN-GGIM convened at UN in New York.
2011	World population reaches 7 billion.
2011	Third Preparatory Meeting to establish UN-GGIM convened at UN in New York.
2011	ECOSOC formally establishes UN-GGIM at its 47 th Plenary Meeting in Geneva, Switzerland.
2011	UN-GGIM convenes its first session and 1 st High Level Forum in Seoul, Republic of Korea.
2012	UN-GGIM Geospatial Societies established at second session of UN-GGIM in New York.
2012	PCGIAP renamed to UN-GGIM for Asia Pacific at the 19 th UNRCC for Asia Pacific in Bangkok.
2013	2 nd High Level Forum on UN-GGIM convened in Doha, Qatar.
2013	PC-IDEA renamed to UN-GGIM Americas at the 10 th UNRCC for the Americas in New York.
2014	UN-GGIM Europe and UN-GGIM Arab States established by UN-GGIM at its fourth session.
2014	3 rd High Level Forum on UN-GGIM convened in Beijing, China.
2015	UNGIWG convenes its last meeting in New York on the margins of the fifth session of UN-GGIM.
2015	UN-GGIM Africa established on margins of the Statistical Commission for Africa, Tunis, Tunisia.
2016	4 th High Level Forum on UN-GGIM convened in Addis Ababa, Ethiopia.
2016	ECOSOC adopts resolution to strengthen and broaden the mandate of UN-GGIM following a 5-year review. Includes the cessation of the UNRCC's for Asia-Pacific and the Americas.
2016	UN-GGIM Academic Network and UN-GGIM Private Sector Network established at sixth session of UN-GGIM.
2017	United Nations Geospatial Network established at seventh session of UN-GGIM.
2017	5 th High Level Forum on UN-GGIM convened in Mexico City, Mexico.
2017	World population reaches 7.5 billion.
2018	First United Nations World Geospatial Information Congress convened in Deqing, China.
2020	6 th High Level Forum on UN-GGIM to be convened in Windsor, United Kingdom.

Figure 3.5: Timeline of geospatial information development in the United Nations.

knowledge each time (Cooper, 2009). In 2009, CODI was replaced (renamed) by the Committee on Development Information, Science and Technology (CODIST), also a subsidiary body of UNECA, which had its first meeting at the UNECA Conference Centre from 28 April to 1 May 2009 (UNECA, 2010).

With the broader objective of incorporating ‘scientific development’ and ‘innovation’, CODIST comprised three Sub-committees: Information and Communication Technologies; Science and Technology and Geoinformation (CODIST-Geo) (UNECA, 2019a). With CODIST placing emphasis on the information society, CODIST-Geo treated mapping and related activities as data collection and processing actions in the overall information management continuum, and also put much effort into the development of an SDI in Africa through the inventory of existing SDIs, the development of a metadata profile for Africa, and human capacity-building activities (UNECA, 2009).

The establishment of these three regional United Nations intergovernmental geospatial information bodies and at a time when SDIs were developing, becoming mainstream, and with mass adoption of geospatial information and a maturation of spatial analysis and modelling, was timely (Scott and Rajabifard, 2017). Geospatial information was increasingly being recognised as an important aspect of the national and regional information infrastructure. These geospatial information technologies, services and platforms were seen as being critical tools to support national development, economic growth, improved decision making and policy formulation, and with the potential to significantly enhance the capability for governments, international organisations and researchers to analyse, model, monitor and report on humanitarian, peace and security, sustainable development, climate change, disasters, and other global development challenges (UN-GGIM, 2015a).

However, the problem with the current situation was that there were no global linkages within governments, industry, academia and the private sector. There was no integration with and purpose for what needed to be achieved in national to global development priorities and agendas. Countries were at different levels of understanding and advancement, and there were disconnected, and scattered approaches being developed, which meant that the subsequent communications of efforts and resources used/required were largely unknown, duplicated or diluted. More importantly, there was no global forum to report issues and other geographic regions of the world were excluded, where such regional mechanisms did not exist. There was no overall ‘glue’ to tie everything together.

Governments did not know where to go or who to seek to learn from each other, particularly for the appropriate guides, frameworks, processes, standards, norms, methodologies and good practices. These are an invaluable resource for developing countries in particular, as they had both limited capabilities and capacities to address these emerging technological innovations. As an example – the role of SDIs in sustainable development. There was limited understanding to their use and benefits and

why they are important. The role and importance of geospatial information was not being realised at the global level and in global development policy.

3.8.2 United Nations Geographic Information Working Group (UNGIWG)

Internally, within the United Nations system and led by technical geospatial practitioners, the United Nations Geographic Information Working Group (UNGIWG)⁷ was formed in 2000 as a voluntary network of United Nations professionals to address common geospatial issues - maps, boundaries, data exchange, standards - that affect the work of UN Organisations and Member States. Its first meeting was convened in March 2000 at the United Nations Headquarters in New York (UNGIWG, 2000; UN-GGIM, 2013b). Meeting annually, UNGIWG's aims were to: improve the efficient use of geographic information for better decision-making; promote standards and norms for maps and other geospatial information; develop core geospatial data to avoid duplication; build mechanisms for sharing, maintaining and assuring the quality of geographic information; and provide a forum for discussing common issues and emerging technological advances (UN-GGIM, 2015a).

In 2005, UNGIWG initiated a process to establish a United Nations Spatial Data Infrastructure (UNSDI) as an infrastructure able to deliver to users integrated spatial information services that can address both technical and non-technical issues ranging from technical standards and protocols, institutional and organisational issues, including data access policy and the creation and maintenance of geospatial information for a wide range of themes (UN-GGIM, 2013b). Much of the motivation was, in the UN context, to promote and achieve sustainable development, improve humanitarian and peacekeeping operations and to promote partnerships and cooperation. Building upon the work of the Global Spatial Data Infrastructure Association (GSDI) and the SDI Cookbook (GSDI, 2004) the UNSDI business case was driven by the need to provide spatial data and information, develop common data services, capacity development, and knowledge transfer. By early 2007, a UNSDI strategy, institutional governance framework and associated documents for developing and implementing the UNSDI had been developed (UNGIWG, 2007). Further refinement and discussions on 'means of implementation' continued for the next several years until in 2010, agreement was made to establish a Centre of Excellence for the UNSDI (CoE4UNSDI) Project. The CoE4UNSDI was launched in 2012 at the 12th UNGIWG Plenary Meeting, but by 2014, and with an almost total dependency on extra-budgetary financing being made available – which had not been forthcoming – the CoE concept remained just a concept.

At its 14th Plenary Meeting in New York in May 2014, participants acknowledged that *“the current approach to UNSDI had not met the expectations due to funding and implementation constraints and shortfalls. Given the close collaboration established with UN-GGIM it is natural to focus on interoperability from an inter-agency perspective, to mirror the activities of UN-GGIM at the inter-*

⁷ UNGIWG website here: <http://www.ungiwg.org/>

governmental level. The meeting participants stressed the need to rebrand UNSDI and suggested therefore a UNSDI name change. UNSDI will henceforward refer to the United Nations Spatial Data Initiative to indicate a change of focus on data sharing and collaboration so that tangible and concrete outcomes can be achieved, even if in small steps.” (UNGIWG, 2014, p.9, 10). The longer term and wider institutional and political recognition, or more importantly, mandate, for UNSDI was unfortunately not able to be achieved. The last meeting of UNGIWG was convened in New York, 3-5 August 2015, on the margins of the fifth session of UN-GGIM. No meeting report was produced.

Whilst the demand for geospatial activities within the United Nations is increasing rapidly, the coordination efforts through UNGIWG had been somewhat limited and ‘invisible’ at the strategic level, as their activities predominantly took place at the operational level depending on the requirements by the different departments, offices and agencies. Many of the collaborative geospatial activities occurring within the United Nations have for many years been carried out on a ‘best efforts’ basis. This model poses challenges in terms of sustainability and operability, and that a sustainable governance structure and associated funding streams are priority needs (UN-GGIM, 2015a).

3.8.3 United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM)

Cognisant of the lack of a global mechanism on geospatial information management, in August 2009, the United Nations Statistics Division (UNSD), as Secretariat of the Ninth UNRCC-Americas, which was held in New York from 10-14 August 2009, convened an informal consultative meeting with geospatial information experts from different regions of the world, and discussed how to better coordinate the various regional and global activities on geospatial information and the related management issues. Subsequent to the consultative meeting, UNSD convened a first preparatory meeting for a proposed ‘United Nations Committee on Global Geographic Information Management’ on 25 October 2009 with Member States and regional and global experts on the margins of the Eighteenth UNRCC-AP, held at UNESCAP Headquarters in Bangkok, Thailand, from 26-29 October 2009. The purpose of the meeting was to discuss how to better coordinate the various regional and global activities on geospatial information and related management issues. It provided an opportunity to reflect upon the challenges at the global level, and how they should be met, in particular with reference to the development and management of national, regional and global geospatial information to support decision-making in an increasingly complex world (UN-GGIM, 2015a). As President of both PCGIAP, and then the Eighteenth UNRCC-AP, the researcher was intimately involved in the discussions (Scott, 2009b) and led the subsequent proposals during the plenary of the UNRCC-AP to tackle outstanding global issues and for more effective coordination by enhancing global geographic information management; for a draft resolution on global geographic information management to be prepared; and that another preparatory meeting be organised in 2010 (United Nations, 2009, para. 44 and 50).

At the conclusion of the Conference, the UNRCC-AP adopted resolution 7 entitled ‘Global geographic information management’ requesting that *“by 1 November 2010, the Secretary-General and the United Nations Secretariat initiate discussions and prepare a report, for a future session of the Economic and Social Council, on global coordination of geographic information management, including consideration of the possible creation of a United Nations global forum for the exchange of information between countries and other interested parties, and in particular for sharing best practices in legal and policy instruments, institutional management models, technical solutions and standards, interoperability of systems and data, and sharing mechanisms that guarantee easy and timely accessibility of geographic information and services.”* (United Nations, 2009, p. 16-17).

In February 2010, at the 41st session of the United Nations Statistical Commission, the issue of global geospatial information management was brought to the attention of the Commission by Brazil and called for a report on a global vision for geographic information management, including the possibility of creating a global forum (United Nations, 2010a). In making decision 41/110 the Commission requested the Secretary-General to initiate discussions and prepare a report for the approval of ECOSOC on the global coordination of geospatial information management, including the consideration of the possible creation of a global forum (United Nations, 2010b).

In May 2010, a second preparatory meeting of the proposed United Nations Committee on Global Geographic Information Management was convened in New York (United Nations, 2010c). The purpose of the meeting was to discuss and initiate the preparation of a report for the approval of ECOSOC, including to develop detailed proposals on the scope and the modalities of the global mechanism for adoption in 2011 (Scott, 2010; UN-GGIM, 2015a). At the meeting, the Republic of Korea offered to host a Global Forum in the second half of 2011 to stimulate the dialogue (United Nations, 2010c).

In July 2010, at its 43rd plenary meeting, ECOSOC, recalling resolution 7 of the Eighteenth UNRCC-AP and decision 41/110 of the Statistical Commission, requested the Secretary-General to submit to the Council at its substantive session of 2011, a report on global geographic information management under the sub-item entitled ‘Cartography’ (United Nations, 2010d).

In April 2011, a third preparatory meeting of the proposed United Nations Committee on Global Geographic Information Management was convened in New York (United Nations, 2011a) to finalise the report for submission and approval of ECOSOC, and to discuss the future activities of the Committee, including the high level forum to be held in Seoul, Korea, in October 2011.

At its 47th plenary meeting on 27 July 2011 in Geneva, ECOSOC considered the report of the Secretary-General on global geographic information management (United Nations, 2011b). The report proposed the establishment of a United Nations Committee of Experts on Global Geospatial

Information Management⁸ as an intergovernmental platform for discussion on global geospatial information management issues, and to bring the regional perspectives together in a coordinated way. The report included proposed terms of reference of the Committee of Experts (United Nations, 2011b).

Recognising the urgent need to take concrete action to strengthen international cooperation in the area of global geospatial information management, ECOSOC adopted resolution 2011/24 which established UN-GGIM as the apex intergovernmental mechanism for geography (United Nations, 2011c). UN-GGIM was established to make joint decisions and set directions with regard to the production and use of geospatial information within national, regional and global policy frameworks; promote common principles, policies, methods, mechanisms and standards for the interoperability of geospatial data and services; and provide a platform for the development of effective strategies on how to build and strengthen national capacity concerning geospatial information, especially in developing countries (United Nations, 2011c). Importantly, the report of the Secretary-General which led ECOSOC to establish UN-GGIM explicitly mentioned the role of geospatial information in informing sustainable development policies, including their monitoring and implementation (United Nations, 2011c).

The inaugural intergovernmental meeting of UN-GGIM (United Nations, 2011d), and first High Level Forum on UN-GGIM (UN-GGIM, 2011b), was convened in Seoul, Republic of Korea, from 24-26 October 2011. The inaugural meeting brought together 350 experts from 90 countries, 22 United Nations representatives and 37 representatives from international organisations and the private sector. The main elements of business were determining the modalities of the Committee of Experts, and how geospatial information can support and contribute to the United Nations Conference on Sustainable Development (Rio+20) (United Nations, 2011d). The High Level Forum, which preceded the intergovernmental meeting, was opened by the Prime Minister of the Republic of Korea and included a Ministerial Segment with Ministers from six countries making statements on the critical role of geospatial information. After three years of preparation, UN-GGIM was established and was off to a very quick and productive start!

In establishing UN-GGIM, ECOSOC encouraged Member States to hold regular high-level, multi-stakeholder discussions on global geospatial information, including through the convening of global forums, with a view to promoting a comprehensive dialogue with all relevant actors and bodies related to geospatial information management (United Nations, 2011c). In the past nine years, concerted efforts have been made by UN-GGIM and the Secretariat to increase the visibility and awareness of the importance and role of geospatial information, as an essential integrative tool to monitor and measure sustainable development, to policy and decision-makers and the diplomatic community. It has quickly engaged with all sectors of the global geospatial community, established relevance, a brand, and a focus

⁸ During the consultation process with Member States, the experts recommended the use of the term ‘geospatial information’ instead of ‘geographic information’ because it is more comprehensive and more commonly used.

that all countries could align to. This has also meant engaging with international organisations, academia and the private sector.

Notably, UN-GGIM has developed a global architecture of technical expert and working groups, and thematic networks, then established a regional architecture in acknowledgement of the regional mechanisms in place, and geographic and cultural differences that exist in geospatial information development. To be able to capture ‘national to regional to global’ issues and perspectives, UN-GGIM considered it a priority to build consensus towards a global-regional UN-GGIM architecture, and strongly linked to its mandates. The role of the associated UNRCC-AP, UNRCC-Americas and CODIST-Geo, as established regional United Nations convening mechanisms on cartography and geospatial technologies, was a valuable and enabling factor in the process (UN-GGIM, 2015a).

To align with the regional architecture of UN-GGIM, in November 2012, PCGIAP was renamed the Regional Committee of United Nations Global Geospatial Information Management for Asia and the Pacific (UN-GGIM-AP) in accordance with resolution 8 ‘Coordination between regional and global initiatives on geospatial information management’ adopted at the Nineteenth UNRCC-AP in Bangkok (United Nations, 2012b, p. 16). At its third session in July 2013, the UN-GGIM Committee of Experts, in making decision 3/114, welcomed the creation of UN-GGIM-AP and invited the regional committee to regularly report to the Committee of Experts (United Nations, 2013b).

This was quickly followed by PC-IDEA which expressed the wish to ‘enhance its role in regional and global geospatial information management by realigning itself with the global architecture, efforts and vision of the UN-GGIM’ (UN-GGIM, 2015a). In August 2013, PC-IDEA was renamed the Regional Committee of United Nations Global Geospatial Information for the Americas (UN-GGIM: Americas) in accordance with resolution 7 ‘Effecting the transition of the Permanent Committee for Geospatial Data Infrastructure of the Americas to the United Nations Global Geospatial Information Management for the Americas’ adopted at the Tenth UNRCC-Americas in New York (United Nations, 2013c, p. 24).

A major incentive for establishing UN-GGIM was to close and bring into the United Nations fold the regional geospatial gaps that existed in Europe and the Arab States. Following a year-long preparatory process, at its fourth session in August 2014 in making decision 4/111, UN-GGIM welcomed and endorsed the establishment of the Regional Committee of United Nations Global Geospatial Information Management for Europe (UN-GGIM: Europe) and the Regional Committee of United Nations Global Geospatial Information Management for the Arab States (UN-GGIM: Arab States), and invited the regional committee’s to regularly report to the Committee of Experts (United Nations, 2014e).

For Africa, the process was a little more convoluted. In August 2011, an African UN-GGIM preparatory meeting recommended African Member States, UNECA and the African Union Commission (AUC) to implement a continental framework toward the active participation of African countries in the newly formed UN-GGIM initiative (UN-GGIM, 2015a). At the third session of CODIST, convened in March 2013, participants resolved that the oversight and supervisory functions of CODIST-Geo be transferred to an equivalent subcommittee of the Statistical Commission for Africa with the name of UN-GGIM: Africa (UNECA, 2014). It is against this background that UNECA organised an inception meeting in Tunis, Tunisia in December 2014 on UN-GGIM in Africa, in parallel with the Statistical Commission for Africa, the outcome being to establish a transitional bureau to implement the establishment of UN-GGIM: Africa (UNECA, 2014). At its fifth session in August 2015, the UN-GGIM Committee of Experts, in making decision 5/112, endorsed the formal establishment of UN-GGIM: Africa, and welcomed the Economic Commission for Africa as the secretariat of the Regional Committee (United Nations, 2015g).

From its inception the Committee of Experts has recognised and encouraged global, regional and national collaboration and capacity building in the promotion and development of geospatial information management for measuring and monitoring sustainable development, and in partnership with the contribution and ongoing role played by other intergovernmental organisations, international non-government organisations, academia and industry in supporting this important global process (UN-GGIM, 2015a). Therefore, at its sixth session in August 2016, noting that the 2030 Agenda calls for stronger public-private partnerships in order for new data sources and technologies to be harnessed, the Committee adopted decision 6/101 establishing the UN-GGIM: Academic Network and the UN-GGIM: Private Sector Network as ‘self-organised’ networks to contribute to and support the activities of UN-GGIM (United Nations, 2016e).

As indicated in Figure 3.6, the global-regional architecture was completed in August 2017 when the Committee of Experts, at its seventh session, agreed to establish a United Nations System Network within its global architecture (United Nations, 2017d, decision 7/115). In August 2019, the Network was renamed the United Nations Geospatial Network (UNGN) to provide clearer branding and communication within the United Nations system. The objectives of the UNGN is to coordinate, collaborate and share mechanisms on geospatial information within the United Nations system, including relevant policies, capacity building, delivery infrastructures and systems, as well as geospatial information management, collection, dissemination, usage and sharing. In endorsing the Network’s terms of reference in August 2018 at its eighth session, UN-GGIM requested that the functions of UNGIWG and the UNGN are consolidated so as to have one efficient mechanism that would build upon the experiences of past coordination efforts (United Nations, 2018b, decision 8/115).

A critical success was having this global-regional architecture formally recognised and established to ensure they are anchored into all UN-GGIM mandates and processes going forward.

Considerable consultation was undertaken by the researcher with Member States to seek validation and agreement on the architecture and its implementation.

In deciding to establish UN-GGIM in 2011 with resolution 2011/24, ECOSOC did so with one critical caveat, that it *“be established and administered within existing resources and organised accordingly, and requests the Committee to present to the Economic and Social Council, in 2016, a comprehensive review of all aspects of its work and operations, in order to allow Member States to assess its effectiveness”* (United Nations 2011c). Despite the 3 years or preparatory work with and by Member States, and despite the ‘urgent need to take concrete action to strengthen international cooperation in the area of global geospatial information management’, ECOSOC did not really understand what the Committee would do or what role geospatial information may have in the global development agendas.



Figure 3.6: The establishment of the UN-GGIM global-regional architecture was completed in August 2017.

To this end, in January 2016 UN-GGIM submitted to ECOSOC a detailed five-year ‘Programme review of the work of the Committee of Experts on Global Geospatial Information Management’ (United Nations, 2016a), prepared in response to the request by ECOSOC described above. On 27 July 2016, ECOSOC adopted resolution 2016/27 on ‘strengthening institutional arrangements on geospatial information management’ (United Nations, 2016f), in which it recognised that UN-GGIM had operated effectively and was well placed to continue to contribute more to the work of the United Nations. ECOSOC decided to strengthen and broaden the mandate of UN-GGIM and invited the Committee to report on ‘all matters relating to geography, geospatial information and related

topics' (United Nations, 2016f). This resolution acknowledges the considerable achievements of UN-GGIM over its first five years, including: its contribution to the strengthening of geospatial information management capacities and utilisation in developing countries; the efforts to streamline the work of the subsidiary bodies of the Council in the field of geospatial information management; and its role in the implementation of the 2030 Agenda for Sustainable Development, the Sendai Framework, and other global development agendas within the purview of the United Nations (United Nations, 2016f).

Another key element of this resolution, and recognition of the influential role of UN-GGIM in establishing its global-regional architecture, was that the formal United Nations Regional Cartographic Conferences are no longer a necessary requirement and, in order to streamline and avoid duplication, that the meetings of the UNRCC-AP and UNRCC-Americas shall cease forthwith (United Nations, 2016f, p.3).

Implementing the 2030 Agenda for Sustainable Development is a principal focus of UN-GGIM. Substantial progress is being made in ensuring the intergovernmental coordination and coherence of geospatial information at the technical level, but the challenge of high-level policy awareness remains and continues to resonate. At its fourth session in August 2014, UN-GGIM observed that *"the level of understanding and rate of uptake of geospatial information, particularly at the policy and decision-making level, remains less than optimal...many do not understand its value and importance within the context of the sustainable development agenda. The production and use of geospatial information within national, regional and global policy frameworks needs to be mainstreamed in order to enhance the capability for governments, international organisations and researchers to analyse, model, monitor and report on sustainable development, disasters, climate change, and other global concerns"* (UN-GGIM, 2014a, p. 10).

At its eighth session in August 2018, UN-GGIM noted that *"many of the efforts being reported to the Committee at this eighth session, as in past sessions, are aligned to providing the required frameworks, methods, standards and guides to assist strengthening national geospatial information capacity-building in developing countries...as a means to facilitate the strengthening and capacity-building of global geospatial information management in support of the implementation of the 2030 Agenda"* (UN-GGIM, 2018a).

In his opening video message to the first United Nations World Geospatial Information Congress, convened in Deqing, China in November 2018, the Secretary-General of the United Nations, António Guterres, stated that *"Your dedication, expertise and guidance - in geospatial data, methods, frameworks, tools, and platforms - is urgently needed. The data needs for the SDGs are great, and time is not on our side. Reliable, timely, accessible and disaggregated geospatial information must be brought to bear to measure progress, inform decision-making and ensure effective and inclusive national and sub-national programs that will chart the path towards the 'Geospatial Way to a Better*

World', to assist in the implementation of the SDGs, and transform our world for the better" (UNWGIC, 2018).

3.9 Chapter Summary

The objectives of this chapter were to provide insights into the evolution and development of geospatial information; its understanding and uptake at the governmental and policy level; the establishment of relevant United Nation's regional to global geospatial information processes and mechanisms such as UN-GGIM; their applicability to the SDGs; and to identify the issues, challenges and impediments to geospatial information contributing more holistically to sustainable development.

Many of the technical hurdles surrounding geospatial information have been aggressively tackled and solved over the past decades, including hardware, software, database and other technological development (Berry, 2013). Therefore, the potential of geospatial information has rapidly advanced and has now reached a level of maturity that allows this information to make a central contribution to the integration of information for the purposes of global issues such as sustainable development.

As can be seen in Figure 3.5, the United Nations has a long history in supporting the intergovernmental processes related to mapping, cartography and geospatial information – longer than with sustainable development processes. But much of the work has been invisible. Following the formal establishment of UN-GGIM in 2011, this visibility and relevance has grown considerably – and now with a global geospatial information mandate and agenda established within the United Nations processes. Similarly, after several years of intense formulation and political negotiations, there is now a definitive global policy agenda for sustainable development with the 2030 Agenda. That said, the strategic frameworks or mechanisms for governments to determine how geospatial information can be implemented and integrated into sustainable development processes, especially at local and national levels, is still lacking. However, for the first time, the global geospatial community, led by UN-GGIM, has a unique opportunity to integrate and connect geospatial information into the global development agenda in a more holistic and sustainable manner, specifically in contributing data towards measuring and monitoring the SDGs.

The next Chapter describes the followed design and methodology for the research in order to answer the research questions and achieve the desired research aim and objectives. The Chapter first investigates the research conceptual design framework by reviewing the research problem and questions, and then discusses and justifies the research method chosen to answer these questions.

Chapter 4 – Research Design and Methodology

4.1 Introduction

Chapters 2 and 3 examined and reviewed the evolution, theory and practice in sustainable development and geospatial information development. Given the research problem, that countries are still unable to adequately contribute their geospatial data, systems and integrative capabilities to support the implementation of the SDGs, the review identified a number of systemic gaps in the understanding of geospatial information and its uptake at the policy level – from national to global – and which informed both the need for the research, as well as the archival data to support it.

This Chapter details the adopted research design and methodology to answer the research questions and achieve the research aim and objectives as described. Research design is an essential instrument and fundamental structure to guide and give direction to research, enabling one to make decisions through the journey from an initial problem or a [set of] research question[s] to reach a suitable answer or solution for them (Bordens and Abbot, 2008). The methodology is further considered as an indication of the validity of the research process (Klein and Myers, 1999).

McBurney et al. (2009) refer to research design as the ‘glue’ that holds all the elements of a research project together. The design also establishes the conceptual structure of investigation, methods of analysis, and procedures that reduce errors and enhance reliability of the results. Saunders et al. (2009) define research as something that people undertake in order to find things out in a systematic way, thereby increasing their knowledge.

Methodology defines the way research should be undertaken. Fisher (2007), formulates the aim of a research methodology as the tools to help the researcher in answering the research question through collecting relevant information. There are different ways in which a researcher can execute research, and determine the quality of that research, relying on the identified method and the suitability of the chosen methods of research (Saunders et al., 2009). Further, research may be defined in terms of a review of current literature and knowledge in a particular field or area, together with the creation of a new branch or slant on this knowledge (Riley et al., 2000).

Saunders et al. (2009) state that the research topic must be something the researcher is capable of undertaking and that excites their imagination. Creswell (2002) recommends that the topic of the research should connect with the career objectives of the researcher, so expertise for this career can be developed (in this researcher’s case; matured). Clough and Nutbrown (2002) use the ‘Goldilocks test’ to decide if research questions are either ‘too big’, ‘too small’, ‘too hot’ or ‘just right’. Research questions that are ‘just right’ are those that are “just right for investigation at *this* time, by *this* researcher in *this* setting” (Clough and Nutbrown, 2002, p.34). Further, McNiff and Whitehead (2000) make the point that the research question may not emerge until the research process has started and is therefore part of the process of ‘progressive illumination’. As articulated in Chapter 1, Section 1.3, regarding the background and motivations of the researcher, these aspects are both relevant and true.

The research problem leverages applied research; its aim being to define, develop, test and apply a conceptual framework, thereby improving understanding of a particular problem. As a descriptive dissertation based on a research philosophy, approach, strategy and case study, to investigate the research questions, this Chapter elaborates the adopted research design and methods, the ‘research onion’ theoretical model developed by Saunders et al. (2009). This research method, with simplicity in approach but also with imposed structure, allows several layers of research and considerations to be available and employed when conducting research. Figure 4.1 illustrates the contents of the six onion layers, and through these, the elements of the research approach itself as highlighted. Saunders’ research onion is a generic research procedure which helps depict issues underpinning the selection of data collection, research methods and a solution to the research problem (Saunders et al., 2009).

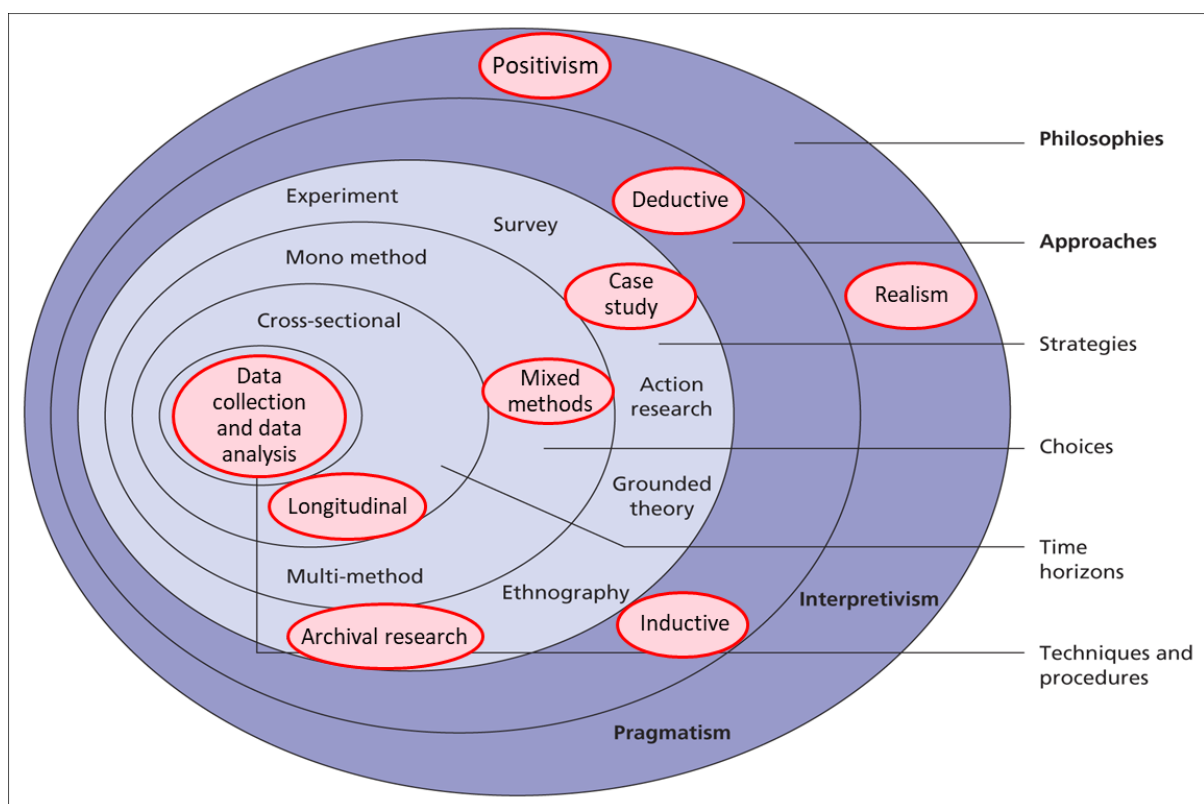


Figure 4.1: The six layers of the ‘research onion’ theoretical method developed by Saunders et al. (2009) with each of the elements chosen for this research (as indicated by the red circles).

The following sections will elaborate each ‘slice of the onion’ – starting from the outermost layer, describing the research choices made, and the justification for the selection of the preferred methodology. The six different layers, or ‘onion slices’ of the model, represent the various stages through which the research must pass when putting together an effective methodology. At each stage, research considerations are able to be taken into account before the core of the onion, the data collection and data analysis, is addressed. By *peeling* back the layers of the research onion one by one, it has been possible to make decisions and choices at each stage in the research process, and this has culminated in

the success of the research. (Saunders et al., 2009). Importantly, all the layers of the onion are essential for the success of the research.

As indicated by the differing colours (darker and lighter blue shades) in Figure 4.1, the outer two layers of the research onion ‘philosophies’ and ‘approaches’, assist how the researcher chooses to answer the research questions for the problem that needs to be solved. The next three layers ‘research strategies’, ‘research choices’ and ‘time horizons’ can be thought of as focusing on the process of research design, turning the research questions into a research project (Robson, 2002).

Research Layer	Research Layer Definitions	Chosen Elements, Reasoning, and Approach for Research
Research Philosophy	Research philosophy is an overarching term relating to the development of knowledge, the nature of that knowledge, and how the knowledge was developed in the research. The beliefs and assumptions the researcher sets at the beginning of the research are the results of how the researcher views and understands the world.	Realism and Positivism: The research has adopted realism (direct and critical) with some positivism elements, and influenced by epistemological assumptions, as they best suit the research topic put forward and the data collection methods and types, and resulting generalisations. Realism objectively assumes a scientific approach to the development of knowledge. Positivism relates to a preference for working with an observable phenomena to provide credible data and facts, and that the end product of such research can be law-like generalisations similar to those produced by physical and natural scientists. Positivism was chosen, as a ‘mixed methods’ approach to the research, as well as heightened levels of observation through the workshops and consultations convened, were required.
Research Approaches	The determination of the research approach is based on the research problem. Describes how the theory is developed and then used in the research through two approaches; deductive and/or inductive.	Deductive and Inductive: Both deductive and inductive approaches have been adopted, although weighted more towards the deductive approach, as the research deduced a hypothesis – to develop a conceptual strategic framework – and then tested the operational hypothesis. A wealth of literature was available to define a theoretical framework and a hypothesis, which then enabled further deduction via the case study. Research using an inductive approach concerns the context in which events are taking place, using more qualitative data, and using a variety of data collection methods. Also, to some extent, the theory was progressively adapted and refined as data were collected.
Research Strategies	The first layer in the research design process and the methodological link between the research philosophy and choice of methods to collect and analyse data. Determines how the research questions are going to be answered and how the data collection and analysis techniques are developed.	Case Study and Archival Research: The research strategies adopted are the case study and archival research methods. Case study provides a rich understanding of a real-life context, and uses and triangulates multiple sources of data. Archival research makes use of administrative records and documents as the principal source of data. The two-dimensional case study, Africa and Ethiopia, provides the researcher with the means to develop, iterate, demonstrate and apply the strategic framework. The archival research provides a new body of knowledge, a historic record of the evolution of sustainable development and geospatial information within the United Nations system and intergovernmental processes, and validates and justifies this research.

Table 4.1: Outer 3 layers of the research methodology, with the reasoning and approach to the research.

The final and inner-most layer, data collection techniques and analysis procedures, concerns what data are needed, and the techniques used to collect the data (Saunders et al., 2009). While detailed in the following Sections, Tables 4.1 and 4.2 summarise the layers of the research methodology, describing each of the elements chosen for the six layers in Figure 4.1, along with the reasoning and approach to the research.

Research Layer	Research Layer Definitions	Chosen Elements, Reasoning, and Approach for Research
Research Choices	Represents the methodological choice to follow a quantitative, qualitative or mixed methods research design. Data collection techniques employed will either use a single data collection and corresponding analysis procedures (mono method), or use more than one data collection technique and analysis procedures (multiple methods) to answer the research question.	Mixed Methods: The research choice employed is mixed method research, with methods being triangulation (case study and archival research data collection methods) and complimentary. The data collection techniques employed are multiple methods, with data collection being initially archival research, and a subsequent two-dimensional case study – with multiple consultations and workshops implemented to collect and validate data iteratively over an 18 month period.
Time Horizons	Represents the time bound limits for the data collection, which can be cross-sectional, such as a single ‘snapshot’ taken as a particular time, or longitudinal, more akin to a ‘diary’ or a series of snapshots taken sequentially at different events over a given period.	Longitudinal: The time horizon employed is a longitudinal time horizon, as it captures a significant amount of archival research (literature), and multiple consultations and workshops with actors involved in the selected two-dimensional case study as a series of ‘snapshots’ over the given research time period.
Techniques and Procedures	Describes the techniques and procedures for the actual data collection in the research	Primary and Secondary Data Collection: The research techniques employed are primary and secondary data collection methods. The national strategic geospatial information framework was first developed with inputs from secondary data, this input stemmed from the considerable literature review and general discussions conducted with global experts over the evolution of UN-GGIM (Chapter 2 and Chapter 3). With deductive analysis (from theory to data), primary data was collected, analysed and validated against the conceptual framework to test the hypotheses. The primary data consisted of detailed presentations, break-out sessions and discussions with experts in consultations in Africa and Ethiopia (Chapter 8).

Table 4.2: Inner 3 layers of the research methodology, with the reasoning and approach to the research.

4.2 Research Philosophy

The first and outer-most layer of the research onion represents the research philosophies that the researcher can take in the development of knowledge, and the nature of that knowledge in a

particular field. A research philosophy is a belief or an idea about the collection, interpretation, and analysis of data collected (Levin, 1988). The researcher adopts this layer in a specific study to reflect important beliefs and assumptions about their opinion and views and the manner in which they understand the world (Simpson, 2009). This will influence the researcher's strategy in relation to the research plan or method they adopt for their research. Indeed, the researcher's specific view and opinion of the association between knowledge and the process by which it is developed is one of the main considerations influencing the choice of a specific philosophy (Saunders et al., 2009).

Whether consciously aware of them or not, at every stage the researcher will make a number of types of assumption (Burrell and Morgan, 1979). These include assumptions about human knowledge (epistemological assumptions), about the realities one encounters in the research (ontological assumptions) and the extent and ways one's values influence their research process (axiological assumptions) (Burrell and Morgan, 1979). These assumptions inevitably shape how the researcher understands their research questions, the methods used and how the findings are interpreted (Crotty, 1998), and are compared and summarised in Table 4.3. The most often used data collection techniques for each research philosophy are also provided for additional comparative context.

Saunders et al. (2009) note that the research philosophy chosen depends on the research question(s), and that the practical reality is that a particular research question rarely falls neatly into only one philosophical domain as suggested in Figure 4.1, and that due to considerable overlap, (Table 4.3) multiple philosophies may be chosen.

As described in Chapter 1, this research is quite broad, initially triggered by (lack of) processes and impacts at the global level, but then anchored to realities and solutions at the national level. It explores the key aspects and impediments as to why geospatial information is not more prominent and integrated into sustainable development processes (at the global level) and provides a new integrative strategic framework that can be used as a tool to solve the problem at the national level. Therefore, it is important to reiterate that this research is applied, descriptive and deductive, and results in a real solution - stemming from a case study approach. More importantly, the research needs are not designed for specific issues for specific countries. The research is not aimed at developing a strategic framework for one, or even a few, countries. It is aimed at being developed for universal implementation by every country in the world, and with a particular application to the SDGs, and with a bias towards Africa to further overcome the digital divide.

Given the above, for this dissertation, the research has adopted the philosophies of realism (direct and critical) with some positivism elements, and influenced by epistemological assumptions, as they best suit the research topic put forward and also the data collection methods and types, and resulting generalisations. Epistemology concerns assumptions about what is acceptable, valid and legitimate knowledge, and how we can communicate knowledge to others (Burrell and Morgan, 1979). Realism

is a branch of epistemology which is similar to positivism in that it objectively assumes a scientific approach to the development of knowledge. This assumption underpins the collection of data and the understanding of those data (Saunders et al., 2009).

Positivism is the approach which is mainly associated with the social and natural sciences, with a preference for working with an observable social reality, that the end product of such research can be law-like generalisations similar to those produced by physical and natural scientists (Remenyi et al., 1998). The researcher also considered positivism as the dissertation intended to use a mixed methods approach to the research and a certain level of observation through the workshops and consultations convened.

4.2.1 Ontology, epistemology and axiology

Saunders et al. (2009) identify these three major methods, or assumptions, of thinking about research philosophy; ontology, epistemology and axiology (Table 4.3). These three branches combine to shape the research philosophy adopted by the researcher (Saunders et al., 2009). Ontology is concerned with the assumptions about the nature of reality, what the researcher believes reality to be and where it exists. This perception of reality is guided by the researcher's belief and understanding of how the world operates. How the researcher views the nature of reality gives rise to two different positions, namely, objectivism and subjectivism (Saunders et al., 2009). Bryman and Bell (2007) discuss that these two positions indicate whether, in the case of objectivism, the researcher believes entities are separate and disassociated from social actors, or with subjectivism, that social phenomena are created and influenced by the actions of these social actors.

The objectivist–subjectivist debate is similar to the different ways in which the theoretical and practical approaches to organisational culture have developed in the past 25 years (Smircich, 1983). Smircich (1983) noted that objectivists would tend to view the culture of an organisation as something that the organisation 'has'. On the other hand, the subjectivist's view would be that culture is something that the organisation 'is' as a result of a process of continuing social enactment.

Epistemology concerns assumptions about what is acceptable, valid and legitimate knowledge, and how we can communicate knowledge to others (Burrell and Morgan, 1979). Whereas ontology may initially seem rather abstract, the relevance of epistemology is more obvious. Different types of knowledge – ranging from numerical data to textual and visual data, from facts to interpretations, and including narratives, stories and even fictional accounts – can all be considered legitimate. This variety of acceptable epistemologies gives the researcher a much greater choice of methods than in many other academic disciplines. However, with this it is important to understand the implications of different epistemological assumptions in relation to the choice of method(s) and the strengths and limitations of subsequent research findings (Burrell and Morgan, 1979).

Research Philosophies	Positivism	Realism	Interpretivism	Pragmatism
Ontology Researcher's view of the nature of reality or being, and where it exists. Reality has two positions; objectivism and subjectivism.	External, objective and independent of social actors.	Is objective. Exists independently of human thoughts and beliefs or knowledge of their existence (realist), but is interpreted through experiences and social conditioning (critical realist).	Socially constructed through culture and language. Subjective, may change. Multiple meanings, interpretations and realities.	Complex, external. Multiple views chosen to best enable answering of research question. Reality is the practical consequence of ideas.
Epistemology Researcher's view regarding what constitutes acceptable, valid and legitimate knowledge. Gives rise to two types of researcher; resources and feelings.	Scientific methods. Only observable phenomena can provide credible data and facts. Focus on causality and law-like generalisations. Reducing phenomena to simplest elements.	Observable phenomena provide credible data and facts. Insufficient data means inaccuracies in sensations (direct realism). Alternatively, phenomena create sensations which are open to misinterpretation (critical realism). Focus on explaining within a context or contexts.	Subjective meanings and social phenomena. Focus upon the details of situation – perceptions and interpretations. A reality behind these details. Subjective meanings motivating actions.	Either or both observable phenomena and subjective meanings can provide acceptable knowledge. Dependent upon the research question. Focus on practical applied research, integrating different perspectives to help interpret the data.
Axiology Researcher's view of the role of values and ethics in research. Values reflect the choices and decisions made and methods selected.	Research is undertaken in a value-free way. The researcher is detached and independent of the data and maintains an objective stance.	Research is value laden. Researcher is biased by world views, cultural experiences and upbringing. These will impact on the research. Is as objective as possible.	Research is value bound. The researcher is part of what is being researched. Cannot be separated and so will be subjective.	Value-driven research. Values play a large role in interpreting results, the researcher adopting both objective and subjective points of view.
Data collection techniques most often used	Typically deductive, highly structured, large samples, measurement, quantitative methods, but can use qualitative.	Range of methods and data types chosen, must fit the subject matter, quantitative or qualitative.	Typically inductive. Small samples, in-depth investigations, qualitative methods of analysis, but range of data can be interpreted.	Follows research problem and question. Range of methods; mixed or multiple method designs, quantitative and qualitative action research.

Table 4.3: Comparison of research philosophies contained within the outer most layer of the research onion. Adapted from Saunders et al. (2009 and 2016).

A core question in this area is whether the social world can be explored and researched in the same way as the natural sciences. How the researcher feels about this core questions will dictate their epistemological outlook in conducting their study (Saunders et al., 2009). Saunders et al. (2009) discuss that this outlook gives rise to two different researchers, namely the ‘resources’ researcher and the ‘feelings’ researcher. The former believes that reality is defined by objects that are ‘real’, objects that

can be counted, enumerated and defined. The latter researcher believes reality is concerned with people's emotions, attitudes and beliefs. The 'resources' researcher would be seen to be adopting a positivist position, whereas the 'feelings' researcher would be seen to be adopting an interpretivist philosophy (Saunders et al., 2009).

Axiology is the branch of philosophy that studies judgements about value, and deals with the role that the researcher's values and ethics play while conducting the research. Heron (1996) argues that our values are the guiding reason for all human action. He further argues that researchers demonstrate axiological skill by being able to articulate their values as a basis for making judgements about what research they are conducting and how they go about doing it. Choosing one topic rather than another suggests that the researcher believes the topic is more important than others. The choice of philosophy is a reflection of one's values, as is the choice of data collection techniques (Heron, 1996). Saunders et al. (2009) emphasise the importance of the researcher's personal values when producing a credible piece of research. They further highlight that the researcher's values will be revealed at all stages throughout the research process; these values are demonstrated in the choices and decisions that are made and methodologies which are selected (Saunders et al., 2009).

4.2.2 Positivism, realism, interpretivism, and pragmatism

Research philosophies show the way in which the researcher is seeing the world, by choosing a research strategy and methods as part of that strategy (Saunders et al., 2009). No philosophy is better than another, but a chosen philosophy affects the researcher's point of view of the relationship between knowledge and the process by which it is developed (Saunders et al., 2009). Johnson and Clark (2006) argue that the important issue is not so much whether research should be philosophically informed, but it is how well the researcher is able to reflect upon their philosophical choices and defend them in relation to the alternatives that could have been adopted. As indicated in Figure 4.1 and elaborated in Table 4.3, the four main research philosophies for consideration are positivism, realism, interpretivism and pragmatism.

Positivism is the approach which is mainly associated with the social and natural sciences, with a preference for working with an observable social reality, that the end product of such research can be law-like generalisations similar to those produced by physical and natural scientists (Remenyi et al., 1998). To generate a research strategy to collect these data the researcher is likely to use existing theory to develop hypotheses. These hypotheses would be tested and confirmed, in whole or part, or refuted, leading to the further development of theory which then may be tested by further research. However, this does not mean that, as a positivist, the researcher necessarily has to start with existing theory (Saunders, et al., 2009).

Another important component of the positivist approach is that the research is undertaken, as far as possible, in a value-free way. For positivists, this is a plausible position because of the measurable,

quantifiable data that they collect. They claim to be external to the process of data collection as there is little that can be done to alter the substance of the data collected (Saunders, et al., 2009). It is frequently advocated that the positivist researcher will be likely to use a highly structured methodology in order to facilitate replication (Gill and Johnson, 2002). If the researcher were to adopt an extreme positivist position, they would see organisations and other social entities as real in the same way as physical objects and natural phenomena are real. Epistemologically they would focus on discovering observable and measurable facts and regularities, and only phenomena that can be observed and measured would lead to the production of credible and meaningful data (Crotty, 1998).

Realism is another philosophical position which relates to scientific enquiry. The essence of realism is that what the senses show as reality is the truth; that there is a reality quite independent of the mind. In this sense, realism is opposed to idealism, the theory that only the mind and its contents exist (Saunders et al., 2009). Realism is a branch of epistemology which is similar to positivism in that it objectively assumes a scientific approach to the development of knowledge. This assumption underpins the collection of data and the understanding of those data. Two forms of realism can be contrasted (Saunders et al., 2009).

Direct realism suggests that what one sees is what they get: what is experienced through the senses portrays the world accurately (Saunders et al., 2009). By contrast, the philosophy of critical realism focuses on explaining what one sees and experiences, in terms of the underlying structures of reality that shape the observable events. For critical realists, reality is the most important philosophical consideration, a structured and layered ontology being crucial (Fleetwood, 2005). Critical realism claims there are two steps to understanding the world. First, there are the sensations and events one experiences. Second, there is the mental processing that occurs sometime after the experience, when one 'reasons backwards' from their experiences to the underlying reality that might have caused them (this reasoning backwards is known as 'retroduction') (Reed, 2005; Saunders et al., 2009). Direct realism proposes that the first step, the sensations and events one experiences, is enough (Saunders et al., 2009).

The direct realist perspective would suggest the world is relatively unchanging and that it operates, in the business context, at one level (the individual, the group or the organisation). The critical realist, on the other hand, would recognise the importance of multi-level study (e.g. at the level of the individual, the group and the organisation). Each of these levels has the capacity to change the researcher's understanding of that which is being studied (Saunders et al., 2009). This would be the consequence of the existence of a greater variety of structures, procedures and processes and the capacity that these structures, procedures and processes have to interact with one another (Saunders et al., 2009).

Interpretivism advocates that it is necessary for the researcher to understand differences between humans in their role as social actors. This emphasises the difference between conducting research among people rather than objects such as trucks and computers. The term ‘social actors’ is quite significant here. Human beings and their social worlds cannot be studied in the same way as physical phenomena; therefore, social sciences research needs to be different from natural sciences research (Saunders et al., 2009). With its focus on complexity, richness, multiple interpretations and meaning-making, interpretivism is explicitly subjectivist. An axiological implication of this is that interpretivists recognise that their interpretation of research materials and data, and thus their own values and beliefs, play an important role in the research process (Saunders et al., 2009). This philosophy also implies that the researcher is part of what is observed and that the research is driven by interests. Saunders et al. (2009) also comment on this approach as having a strong grounding in the research of business and management topics, particularly in such fields as organisational behaviour. Business situations are unique and complex and involve several parties.

Pragmatism asserts that concepts are only relevant where they support action (Kelemen and Rumens, 2008). It strives to reconcile both objectivism and subjectivism, facts and values, accurate and rigorous knowledge and different contextualised experiences (Table 4.3) (Saunders et al., 2009, 2016). It does this by considering theories, concepts, ideas, hypotheses and research findings not in an abstract form, but in terms of the roles they play as instruments of thought and action, and in terms of their practical consequences in specific contexts (Saunders et al., 2009, 2016). For a pragmatist, research starts with a problem, and aims to contribute practical solutions that inform future practice. Researcher values drive the reflexive process of inquiry, which is initiated by doubt and a sense that something is wrong or out of place, and which re-creates belief when the problem has been resolved (Elkjaer and Simpson, 2011). As pragmatists are more interested in practical outcomes than abstract distinctions, their research may have considerable variation in terms of how ‘objectivist’ or ‘subjectivist’ it turns out to be. Pragmatists recognise that there are many different ways of interpreting the world and undertaking research, that no single point of view can ever give the entire picture and that there may be multiple realities (Kelemen and Rumens, 2008; Saunders et al., 2016).

4.3 Research Approach

The second ‘slice’ of the research onion (Figure 4.1) is the research approach. According to Creswell (2009), the determination of the research approach is based on the research problem. Research involves the use of theory which may or may not be made explicit in the design of the research but is usually present in the results and conclusions (Creswell, 2009). In the notion of Saunders et al. (2009), the design of the research depends on the extent to which the theory is clear at the beginning of the research. In this regard, there are two different approaches; deductive and inductive.

In this research design both deductive and inductive approaches have been adopted, although it is weighted more towards the deductive approach, as the research aim was to deduce a hypothesis – to develop a conceptual strategic framework – and then test the operational hypothesis via a two-dimensional case study. However, research using an inductive approach is likely to be particularly concerned with the context in which such events were taking place (Saunders et al., 2009); in this research, in the context of the 2030 Agenda and the SDGs. Also, to some extent, the theory was developed and refined further as the data were collected. For example, as the research evolved it became apparent that the development and implementation of a national strategic geospatial framework could not be achieved without considering the significant dependencies on geospatial data and emerging technologies, bridging the geospatial digital divide, and an integrated geospatial information systems framework (Figure 1.2).

With the deductive approach, the researcher develops a theoretical framework and hypothesis (or hypotheses) and designs a research strategy to test the hypothesis in the field (Saunders et al., 2009). The deductive approach is the dominant research approach in the natural sciences where laws present the basis of explanation, allow the anticipation of phenomena, predict their occurrence and therefore permit them to be controlled (Collis and Hussey, 2003). Creswell (2002) suggests a topic on which there is a wealth of literature from which the researcher can define a theoretical framework, a hypothesis lends itself more readily to deduction. Blaikie (2010) lists six sequential steps through which a deductive approach will progress, and which were applied to this research:

1. Put forward a tentative idea, a premise, a hypothesis (a testable proposition about the relationship between two or more concepts or variables) or set of hypotheses to form a theory – in this case, a conceptual strategic framework;
2. By using existing literature, or by specifying the conditions under which the theory is expected to hold, deduce a testable proposition or number of propositions – the components (principles, goals and strategic pathways of the framework;
3. Examine the premises and the logic of the argument that produced them, comparing this argument with existing theories to see if it offers an advance in understanding. If it does, then continue – comparison with existing sustainable development and SDI practices and frameworks;
4. Test the premises by collecting appropriate data to measure the concepts or variables and analysing them – a series of interactive workshops and consultations, and country case study;
5. If the results of the analysis are not consistent with the premises (the tests fail), the theory is false, and must either be rejected or modified, and the process restarted; and
6. If the results of the analysis are consistent with the premises, then the theory is corroborated.

An important characteristic of deduction is that it is highly structured, and concepts need to be operationalised in a way that enables facts to be measured quantitatively (Saunders et al., 2016). Another characteristic is generalisation. In order to be able to generalise statistically about regularities

in human social behaviour it is necessary to select samples of sufficient numerical size (Saunders et al., 2016). Finally, in order to pursue the principle of scientific rigor, deduction dictates that the researcher should be independent of what is being observed (Saunders et al., 2009).

Conversely, the inductive approach enables the researcher to collect data and develop theory as a result of the data analysis (Saunders et al., 2009). The inductive approach is mostly used in qualitative research and makes it possible to explore a social phenomenon to obtain empirical patterns that operate as the start of a theory (Bryman, 2008). When using the inductive approach data are collected and a theory is formed using the results of the data analysis (Saunders et al., 2009). Followers of induction would criticise deduction because of its tendency to construct a rigid methodology that does not permit alternative explanations of what may be occurring. In that sense, there is an air of finality about the choice of theory and definition of the hypothesis. Alternative theories may be suggested by deduction. However, these would be within the limits set by the highly structured research design (Saunders et al., 2009). Research using an inductive approach is likely to be particularly concerned with the context in which such events were taking place. Therefore, the study of a small sample of subjects might be more appropriate than a large number as with the deductive approach. Insofar as it is useful to attach these research approaches to the different research philosophies, deduction owes more to positivism and induction to interpretivism (Saunders et al., 2009).

According to Saunders et al. (2009), not only is it perfectly possible to combine both deductive and inductive approaches within the same research, it is often an advantage to do so. Creswell (2002) suggests a number of practical criteria. The most important of these are the emphasis of the research and the nature of the research topic. A topic on which there is a wealth of literature from which one can define a theoretical framework and a hypothesis lends itself more readily to deduction (Creswell, 2002). With research into a topic that is new, is exciting much debate, and on which there is little existing literature, it may be more appropriate to work inductively by generating data and analysing and reflecting upon what theoretical themes the data are suggesting (Creswell, 2002).

The time available is another issue. Deductive research can be quicker to complete, albeit that time must be devoted to setting up the study prior to data collection and analysis. Data collection is often based on 'one take'. It is normally possible to predict the time schedules accurately. On the other hand, inductive research can be much more protracted. Often the ideas, based on a much longer period of data collection and analysis, have to emerge gradually (Saunders et al., 2009).

4.4 Research Strategy

While being the third ring in the research onion, the research strategy is the first layer in the actual research design process (Figure 4.1). It is how a research question is turned into a research project (Robson, 2002). It is the methodological link between the research philosophy and subsequent choice of methods to collect and analyse data (Denzin and Lincoln, 2011). The research question prompts the

researcher to think about the purpose of the research, which then informs the choice of research strategy, choices of collection techniques and analysis procedures, and the time horizon over which the research project is undertaken (Denzin and Lincoln, 2011). According to Robson (2002), the classification of research purpose most often used in the research methods' literature is the threefold; one of exploratory, descriptive and explanatory. However, in the same way as the research question can be both descriptive and explanatory, so the research project may have more than one purpose.

An exploratory study allows the researcher to gain an insight into 'what is happening' in a particular area and to gain insights into existing phenomena in a new light (Robson, 2002). Saunders et al. (2009) suggest that there are three principal ways of conducting exploratory research: a search of the literature; interviewing 'experts' in the subject; or conducting focus group interviews. Adams and Schvaneveldt (1991) reinforce the point that the flexibility inherent in exploratory research does not mean absence of direction to the enquiry. What it does mean is that the focus is initially broad and becomes progressively narrower as the research progresses (Adams and Schvaneveldt, 1991). The object of descriptive research is 'to portray an accurate profile of persons, events or situations' (Robson, 2002). A descriptive study is explained as giving a clearer picture of already known phenomena and can be an extension of, or a forerunner to, a piece of exploratory research or, more often, a piece of explanatory research. It is necessary to have a clear picture of the phenomena on which the researcher wishes to collect data prior to the collection of the data (Robson, 2002). Studies that establish causal relationships between variables may be termed explanatory research. The emphasis is on studying a situation or a problem in order to explain the relationships between variables (Saunders et al., 2009).

Saunders et al. (2009) emphasise that the choice of a research strategy is made according to the research question(s) and objectives, the extent of existing knowledge, the time period and available resources, and also the philosophical substantiation of the researcher. As indicated in Figure 4.1, there are seven research strategy methods available that may be employed: experiment; survey; case study; action research; grounded theory; ethnography; and archival research (Saunders et al., 2009). Each strategy can be used for exploratory, descriptive and explanatory research (Yin 2003). Some of these clearly belong to the deductive approach, others to the inductive approach. However often allocating strategies to one approach or the other is unduly simplistic. In addition, none of them is superior or mutually exclusive (Saunders et al., 2009).

As described in Chapter 1 in defining the research problem (Section 1.2.1) there is presently no evident national strategic frameworks, roadmaps or federated geospatial infrastructure for governments to determine how geospatial information can be implemented and integrated into the SDGs, as an enabling technology, especially at local and national levels. This lack of frameworks and guidance, with commensurate critical gaps and connection points with national geospatial methods and infrastructures, is a visible impediment to developing countries and those most affected by the challenges and need to achieve national development.

Given the breadth and local to global dimensions and reach of the research problem and aim described in Chapter 1, and in considering the ensuing research questions (Section 1.2.2), the most suitable research strategies adopted for this research are the case study and archival research methods. Case study provides a rich understanding of a real-life context, and uses and triangulates multiple sources of data. Archival research makes use of administrative records and documents as the principal source of data (Saunders et al., 2009). Triangulation refers to the use of different data collection techniques within one study in order to ensure that the data are telling the researcher what they think the data are telling them (Saunders et al., 2009). Triangulation was used in this research, as two independent sources of data collection methods were used to corroborate the research findings; the archival research as detailed in Chapters 2 and 3, and the case study as detailed in Chapter 8.

Yin (2003) distinguishes between four case study strategies based upon two discrete dimensions: single case v. multiple cases; and holistic case v. embedded case. This research employed single case and holistic case study strategies. A single case is often used where it represents a critical case or, alternatively, an extreme or unique case. Yin's (2003) second dimension, holistic v. embedded, refers to the unit of analysis. If the research is concerned only with the organisation as a whole, then it is treating the organisation as a holistic case study.

The case study approach provided the researcher with the means to develop, iterate, demonstrate and implement the strategic framework. Given the context of the research problem and aim, that 'developing countries' are those most affected by the challenges and need to achieve national development, the case study for this research is primarily the continent of Africa. Africa represents an extreme and unique case of lack of opportunity and means to develop national geospatial methods and infrastructures. Further, the researcher was of the opinion that if such a strategic framework could be developed and implemented in Africa, a continent containing 54 countries and 33 of the world's LDCs, it could then be implemented in any and every country. However, given the need to ensure 'national implementation' the case study also delves into a country example, Ethiopia, to extract some of the pertinent issues in solving the research questions. Therefore the data for the research was collected at two levels and in two phases – through four highly interactive and structured consultations and workshops convened over 18 months from April 2018 to November 2019 with African countries; and through a number of detailed survey templates provided to the Ethiopian Geospatial Information Institute's senior management and related stakeholders for completion in a group setting at their own pace and in their own time (Chapter 8).

Given the very limited capacities and resources available to geospatial experts in Africa, the case study data collection for African countries, through the four highly interactive and structured regional workshops and consultations, was undertaken in close collaboration with UN-GGIM Africa and UNECA. This collaboration was both beneficial and in the interests of UN-GGIM Africa, as it provided a means to develop a holistic understanding and ownership of the strategic framework – and

a much needed ‘plan of action’ moving forward. The ensuing discussions were the most efficient way to iteratively develop and then rigorously determine the structure and content of the framework. Workshop participants were selected based on their national roles, expertise, knowledge and understanding of the technical language and related processes for national spatial data infrastructures. Workshops, or focus groups, is a suitable method for *"exploring the views, experiences, beliefs and/or motivations of individuals on specific matters"* (Gill et al., 2008). They are also beneficial for the purpose of evaluation in this research because they:

- Allow for direct iteration and presentation of the structure of the framework and the underlying processes;
- Include an interactive dialogue and engagement with the national country delegates that allow for capturing their responses in a greater way than other methods (and in particular survey method);
- Ensure that the selected national experts actually understand and ‘own’ the framework, and build a ‘community of interest’ in a consensus-driven manner in its implementation;
- Are less susceptible to the low-response and non-interactive risk associated with the questionnaire or other methods; and
- Allow for tailoring the workshops to individual requirements in order to capture the unique needs and experiences.

In addition, due to the complexity of the strategic framework, additional information (e.g. relationship to NSDIs) can be provided to the participants immediately on the spot. For these reasons, structured interactive workshops were adopted as the main data collection method.

The subsequent case study data collection in Ethiopia, through survey templates, provided the means to trial and assess the implementation of the framework at a national level for this research. Conducted in collaboration with the Ethiopian Geospatial Information Institute, Ethiopia’s national mapping agency, the surveys included a Current and Desired Performance Survey, a Baseline Survey, and an Environmental Scan (Chapter 8, Section 8.4.2.1). The data collected enabled the researcher to then compile a consolidated analysis as a Needs Assessment and Gap Analysis matrix for implementation of the strategic framework.

A Needs Assessment is a systematic process for examining and framing the difference between an organisation’s current standing and its desired performance and improvement opportunities (Gupta, 2011; Jannetti, 2012). It can be initiated in response to a problem or opportunity, or used in ongoing learning or performance improvement efforts. A Needs Assessment gathers information that is appropriate and sufficient to develop an effective program that will address an organisation’s needs and wants (gap) for the future. Similarly, a gap analysis is a procedure to identify shortcomings, or gaps, in

the organisation's processes that stand in the way of achieving strategic objectives (Gupta, 2011; Jannetti, 2012).

Archival research makes use of administrative records and documents as the principal source of data (Saunders et al., 2009). Although the term archival has historical connotations, it can refer to recent as well as historical documents (Bryman, 1989). An archival research strategy allows research questions which focus upon the past and changes over time to be answered, be they exploratory, descriptive or explanatory. However, the ability to answer such questions will inevitably be constrained by the nature of the administrative records and documents (Saunders et al., 2009). The archival research in this dissertation comprises the detailed literature examination and review captured in Chapter 2: sustainable development theory and practice, and the relationships with and role of geospatial information; and Chapter 3: the evolution and development of geospatial information, its understanding and uptake at the intergovernmental level, its applicability to the SDGs, existing mechanisms and initiatives, and the issues and challenges that impede geospatial information contributing more holistically to sustainable development.

Given the nature of these reviews, and the associated evolution and history, a focus for the researcher was an analysis of the existing United Nations processes within the literature. This provided considerable background context as to why the research problem statement has been developed. That *'despite the demonstrated demand and global development need, the problem is that geospatial information is still unable to adequately contribute its data, systems and integrative capabilities to support implementation of the SDGs and targets of the 2030 Agenda for Sustainable Development, particularly at a national level.'* The archival research provided a new body of knowledge, providing a historic record of the evolution of sustainable development and geospatial information within the United Nations system and intergovernmental processes, and validated the justification for this research. It reiterated that not only do countries continue to lack important baseline data and enabling technologies to help guide development, national governments remain a considerable distance from fully developing and implementing the required policies and frameworks to ensure that development progress, including appropriate interventions, is effective, measurable, and sustainable.

4.4.1 Experiment

Experiment is a form of research that owes much to the natural sciences, although it features strongly in much social science research, particularly psychology (Saunders et al., 2009). The purpose of an experiment is to study causal links; whether a change in one independent variable produces a change in another dependent variable (Hakim, 2000). The simplest experiments are concerned with whether there is a link between two variables. More complex experiments also consider the size of the change and the relative importance of two or more independent variables. Experiments therefore tend to be used in exploratory and explanatory research to answer 'how' and 'why' questions (Saunders et al., 2009). Inevitably, an experimental strategy will not be feasible for many business and management

research questions, as some subjects are not willing to participate in experiments, and those who do volunteer may not be representative (Saunders et al., 2009). Therefore, this strategy was not appropriate for this research.

4.4.2 Survey

The survey is a popular and common strategy in business and management research and is most frequently used to answer ‘who’, ‘what’, ‘where’, ‘how much’ and ‘how many’ questions. It therefore tends to be used for exploratory and descriptive research, and is usually associated with the deductive approach (Saunders et al., 2009). Surveys are popular as they allow the collection of a large amount of data from a sizeable population in a highly economical way. Often obtained by using a questionnaire administered to a sample, these data are standardised, allowing easy comparison. In addition, the survey strategy is perceived as authoritative and is relatively easy to explain and to understand (Saunders et al., 2009).

The survey strategy allows the researcher to collect quantitative data which can be analysed quantitatively using descriptive and inferential statistics. In addition, the data collected can be used to suggest possible reasons for particular relationships between variables and to produce models of these relationships (Saunders et al., 2016). A survey provides more control over the research process and, when sampling is used, it is possible to generate findings that are representative of the whole population at a lower cost than collecting the data for the whole population (Saunders et al., 2009). However, there are drawbacks. There is a limit to the number of questions that any questionnaire can contain, and there is a heavy reliance on respondents actually responding (Saunders et al., 2016). Given the research process was iterative, based on a small population within a ‘multiple’ workshop and consultation environment, this strategy was not conducive to this research.

4.4.3 Case study

Robson (2002) and Yin (2014) define case study as a strategy for doing research which involves an empirical investigation of a particular contemporary topic or phenomenon within its real-life context using multiple sources of evidence. There are several reasons for using this method. First, the possibility to gain a full understanding of the context of the research and the processes therein (Morris and Wood, 1991). Secondly, the case study method is a common strategy in business and management studies research. It has considerable ability to generate answers to the question ‘why’ as well as the ‘what’ and ‘how’ questions, although ‘what’ and ‘how’ questions tend to be more the concern of the survey strategy. For this reason, the case study strategy is most often used in explanatory and exploratory research (Saunders et al., 2009).

The ‘case’ in case study research may refer to a person, a group, an organisation, an association, a change process, an event as well as many other types of case subject (Yin, 2003). Yin (2003) highlights that understanding context is fundamental to case study research, which is often used when the

boundaries between the phenomenon being studied and the context within which it is being studied are not always apparent. A case study strategy has the capacity to generate insights from intensive and in-depth research leading to rich, empirical descriptions and the development of theory (Dubois and Gadde, 2002; Eisenhardt, 1989; Eisenhardt and Graebner, 2007; Ridder et al., 2014; Yin, 2014). To achieve such insights, case study research draws on quantitative or qualitative research and frequently uses a mixed method (Section 4.5) approach, to understand fully the dynamics of the case (Saunders et al., 2009).

According to Saunders et al. (2009), the data collection techniques employed may be various and are likely to be used in combination. They may include, for example, interviews, observation, documentary analysis and questionnaires. Consequently, using a case study strategy will likely require the need to use and triangulate multiple sources of data (Saunders et al., 2009). Triangulation refers to the use of different data collection techniques within one study in order to ensure that the data are telling the researcher what they think the data are telling them. For example, qualitative data collected using semi-structured group interviews may be a valuable way of triangulating quantitative data collected by other means such as a questionnaire (Saunders et al., 2009).

Yin (2003) distinguishes between four case study strategies based upon two discrete dimensions: single case v. multiple cases; and holistic case v. embedded case. A single case is often used where it represents a critical case or an extreme or unique case. Conversely, a single case may be selected because it is typical or because it provides the researcher with an opportunity to observe and analyse a phenomenon that few have considered before. The rationale for using multiple cases focuses upon the need to establish whether the findings of the first case occur in other cases and, as a consequence, the need to generalise from these findings (Yin, 2003). For this reason, Yin (2003) argues that multiple case studies may be preferable to a single case study and that, where the researcher chooses to use a single case study, they will need to have a strong justification for this choice.

Yin's (2003) second dimension, holistic v. embedded, refers to the unit of analysis. For example, if an organisation is chosen as the case study and the research is concerned only with the organisation as a whole, then the organisation is treated as a holistic case study. Conversely, even though researching and concerned with a single organisation as a whole, if the researcher wishes to also examine a number of logical sub-units within the organisation, then the case will inevitably involve more than one unit of analysis. Whatever way these units are selected, this would be called an embedded case study (Yin, 2003).

4.4.4 Action research

Action research is an emergent and iterative process of inquiry that is designed to develop solutions to real organisational problems through a participative and collaborative approach, which uses different forms of knowledge, and which will have implications for participants and the organisation

beyond the research project (Coghlan and Brannick, 2005; Coghlan, 2011). According to Coghlan and Brannick (2005), there are four common themes within the literature. The first focuses upon and emphasises the purpose of the research: research in action rather than research about action. The second relates to the involvement of practitioners, a community of practice, in the research and, in particular, a collaborative democratic partnership between practitioners and researchers, be they academics, other practitioners or internal or external consultants. The third theme emphasises the iterative nature of the process of diagnosing, planning, taking action and evaluating. The action research spiral commences within a specific context and with a clear purpose. This is likely to be expressed as an objective (Robson, 2002). The final theme suggests that action research should have implications beyond the immediate project; in other words, it must be clear that the results could inform other contexts (Coghlan and Brannick, 2005). For academics undertaking action research, Eden and Huxham (1996) link this to an explicit concern for the development of theory.

Action research differs from other research strategies because of its explicit focus on action, in particular promoting change within the organisation. Therefore, it is particularly useful for ‘how’ questions. In addition, the researcher is involved in this action for change and, subsequently, application of the knowledge gained elsewhere (Saunders et al., 2009). The strengths of an action research strategy are a focus on change, the recognition that time needs to be devoted to diagnosing, planning, taking action and evaluating, and the involvement of employees (practitioners) throughout the process (Saunders et al., 2009). However, such a research strategy was not suitable for this research, as a journey of discovery and change within an organisational environment was considered more valuable and achievable than an explicit ‘action orientated’ approach.

4.4.5 Grounded theory

Grounded theory can be thought of as ‘theory building’ through a combination of induction and deduction (Saunders et al., 2009). A grounded theory strategy is, according to Goulding (2002), particularly helpful for research to predict and explain behaviour, the emphasis being upon developing and building theory. In grounded theory, data collection starts without the formation of an initial theoretical framework. Theory is developed from data generated by a series of observations. These data lead to the generation of predictions which are then tested in further observations that may confirm, or otherwise, the predictions (Saunders et al., 2009). Constant reference to the data to develop and test theory leads Collis and Hussey (2003) to call grounded theory an inductive/deductive approach, theory being grounded in such continual reference to the data. Suddaby (2006) contends that with grounded theory the key issue to remember is that it is an interpretive process, not a logico-deductive one, and the researcher should treat it as highly creative. Further, Suddaby (2006) warns that grounded theory is not perfect. By its nature it is ‘messy’. It requires researchers to develop a tacit knowledge of, or feel for, their data (Suddaby, 2006). Therefore, given the nature of this research, and that the case study

focusses on some of the world's LDCs, a grounded theory approach was not considered suitable for this research.

4.4.6 Ethnography

Ethnography emanates from the field of anthropology and is used to study the culture or social world of a group. Simply stated, it is the study of people in their own environment through the use of methods such as participant observation and face-to-face interviewing (Saunders et al., 2016). This is a research strategy that is very time consuming and takes place over an extended time period, as the researcher needs to immerse themselves in the social world being researched as completely as possible (Saunders et al., 2009). The research process needs to be flexible and responsive to change since the researcher will constantly be developing new patterns of thought about what is being observed. Although not a dominant research strategy in business, ethnography may be very appropriate if the researcher wishes to gain insights about a particular context and better understand and interpret it from the perspective(s) of those involved (Saunders et al., 2009). With such a research strategy, the researcher needs to build a high degree of trust with research participants and develop strategies to cope with being both a full-time member of the social context in which the research is set, as well as undertaking the research (Saunders et al., 2009). Such an immersive approach by the researcher was not feasible for this research.

4.4.7 Archival research

Archival research makes use of administrative records and documents as the principal source of data (Saunders et al., 2009). An archival research strategy allows research questions which focus upon the past and changes over time to be answered, be they exploratory, descriptive or explanatory. However, the ability to answer such questions will inevitably be constrained by the nature and availability of the administrative records and documents (Saunders et al., 2009). Today, the digitalisation of data and the creation of online archives have increased the scope to use an archival or documentary research strategy. Because of the Internet and the digitalisation of university-based, governmental, organisational and media documents and other data, it is now possible to access such sources from around the world at any time. This potentially provides the researcher with considerable scope to design a research project that capitalises on a wide range of available data sources (Saunders et al., 2016).

However, even where these records exist, they may not contain the precise information needed to answer the research question(s) or meet the researcher's objectives. Therefore, using an archival research strategy necessitates establishing what data are available, and that they were not originally created for a research purpose, and designing the research to make the most of it (Saunders et al., 2009). While great care needs to be taken when using documents for research purposes, they potentially offer a rich source of data to analyse. The data they provide may be quantitative, qualitative or both. Using qualitative documents may allow the researcher to generate a rich description of key events, the context

within which these events occurred, the roles of the actor's involved, decision-making processes, the influence of external influences, or different policy positions or strategies (Saunders et al., 2009).

4.5 Research Choice

Based on the research questions and the researcher's objectives for this research, this dissertation employed mixed method research, with methods being triangulation (case study and archival research data collection methods) and complimentary.

According to Saunders et al. (2009), the first methodological choice is whether the researcher follows a quantitative, qualitative or mixed methods research design. The terms 'quantitative' and 'qualitative', already mentioned several times in this chapter, are commonly used to differentiate both data collection techniques and data analysis procedures (Saunders et al., 2009). Each of these options is likely to call for a different mix of elements to achieve coherence in the research design. Quantitative research is a method that predominantly uses numerical data such as a questionnaire, graphs or statistics, or other data analysis procedure. Qualitative research is a method that predominantly uses non-numerical data, including words, interview, pictures and video clips rather than quantification in the collection and analysis of data (Saunders et al., 2009). As reflected in Figure 4.1, Saunders et al. (2009) refer to the way in which the researcher chooses to combine quantitative and qualitative techniques and procedures as 'research choices.'

Individual quantitative and qualitative techniques and procedures do not exist in isolation. In choosing research methods (Figure 4.2) the researcher will either use a single data collection technique and corresponding analysis procedures (mono method) or use more than one data collection technique and analysis procedures to answer the research question (multiple methods) (Saunders et al., 2009). A mono method will combine either a single quantitative data collection technique, such as questionnaires, with quantitative data analysis procedures; or a single qualitative data collection technique, such as in-depth interviews, with qualitative data analysis procedures. Multi-method refers to those combinations where more than one data collection technique is used with associated analysis techniques, but this is restricted within either a quantitative or qualitative world view (Tashakkori and Teddlie 2003).

Thus, the researcher might choose to collect quantitative data using, for example, both questionnaires and structured observation analysing these data using statistical (quantitative) procedures, a multi-method quantitative study (Saunders et al., 2009). Alternatively, they might choose to collect qualitative data using, for example, in-depth interviews and diary accounts and analyse these data using non-numerical (qualitative) procedures, a multi-method qualitative study. Therefore, if the researcher adopted a multi-methods study, they would not mix quantitative and qualitative techniques and procedures (Saunders et al., 2009).

Mixed methods approach is the general term for when both quantitative and qualitative data collection techniques and analysis procedures are used in a research design (Figure 4.2) (Saunders et

al., 2009). It is subdivided into two types. Mixed method research uses both quantitative and qualitative data collection techniques and analysis procedures either at the same time (parallel) or one after the other (sequential) but does not combine them (Saunders et al., 2009). This means that, although mixed method research uses both quantitative and qualitative world views at the research methods stage, quantitative data are analysed quantitatively, and qualitative data are analysed qualitatively. In contrast, mixed-model research combines quantitative and qualitative data collection techniques and analysis procedures as well as combining quantitative and qualitative approaches at other phases of the research, such as research question generation (Saunders et al., 2009).

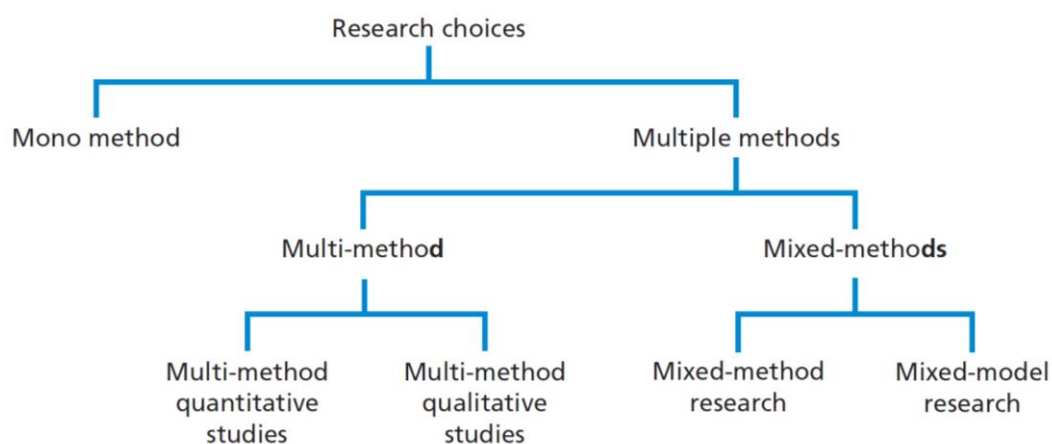


Figure 4.2: Research choices used in research design (Saunders et al., 2009).

Tashakkori and Teddlie (2003) argue that multiple methods are useful if they provide better opportunities to answer research questions and where they allow the researcher to better evaluate the extent to which the research findings can be trusted and inferences made from them. The major advantage to choosing to use multiple methods in the same research project is that different methods can be used for different purposes in a study. The researcher may wish to employ, for example, interviews at an exploratory stage, in order to get a feel for the key issues before using a questionnaire to collect descriptive or explanatory data. This would give confidence that the researcher was addressing the most important issues (Saunders et al., 2009).

Smith (1981) argues that quantitative and qualitative data collection techniques and analysis procedures each have their own strengths and weaknesses. There is inevitably a relationship between the data collection technique chosen and the results obtained. The results will be affected by the techniques and procedures used (Saunders et al., 2009). The problem here is that it is impossible to ascertain the nature of that effect. Since all different techniques and procedures will have different effects, it makes sense to use different methods to cancel out the 'method effect'. That will lead to greater confidence being placed in the research conclusions (Saunders et al., 2009).

Bryman (2006) identifies the main reasons and explanations for mixed method research, one of them being triangulation – the use of two or more independent sources of data or data collection methods to corroborate research findings within a study. Another is complementarity – the use of two or more research strategies in order that different aspects of an investigation can be dovetailed (e.g. qualitative plus quantitative questionnaire to fill in gaps, quantitative plus qualitative questionnaire for issues, and interview for meaning) (Bryman, 2006).

4.6 Time Horizon

This research employs a longitudinal time horizon, as it has captured a significant amount of archival research (literature), and multiple consultations with actors involved in the case study which have been undertaken over time. This time horizon has borne fruit.

According to Saunders et al. (2009), an important consideration in planning research is the time horizon, which in turn is dependent on the research question, and whether it is to be a single ‘snapshot’ taken at a particular time (cross-sectional), or more akin to a ‘diary’ or a series of snapshots taken sequentially at different events over a given period (longitudinal) (Figure 4.1).

Cross-sectional research, the study of a particular phenomenon (or phenomena) at a particular time, is common for research projects for academic courses that are necessarily time constrained. These studies often employ the survey strategy or case studies based on interviews conducted over a short period of time (Saunders et al., 2009). As such, the cross-sectional approach was not considered conducive to this research. In contrast, the main strength of longitudinal research is the capacity to study change and development (Saunders et al., 2009). Adams and Schvaneveldt (1991) point out that in observing people or events over time, the researcher is able to exercise a measure of control over variables being studied, provided that they are not affected by the research process itself.

As there is a large amount of published data and literature relating to geospatial information management collected over time, the longitudinal approach has provided the opportunity to study the evolution of geospatial information management, and capture and analyse this information in terms of the experience of developed and developing nations. These previous works, popularised over time, have since informed this research and the development of the frameworks espoused.

4.7 Techniques and Procedures

This research was conducted using both primary and secondary data collection for the dissertation question. Data collection and data analysis is the final and inner most layer of the research onion. Saunders et al. (2009) describe primary data collection as information generated by the researcher through their interest and the specific motivation of the study, whilst secondary data is information coming from existing sources.

As will become evident in the following Chapters of this dissertation, achieving the research aim has required addressing multiple ‘precursors’ before developing and applying the strategic framework itself. Figure 4.3 provides relevant context for the structure of this dissertation, as well as the design of the research. The theoretical framework was first developed with inputs from secondary data, this being the in-depth literature review and many discussions with global experts over the evolution of UN-GGIM (Chapters 2 and 3) to understand and then address the problem statement, a problem that is more than half a century in its curation.

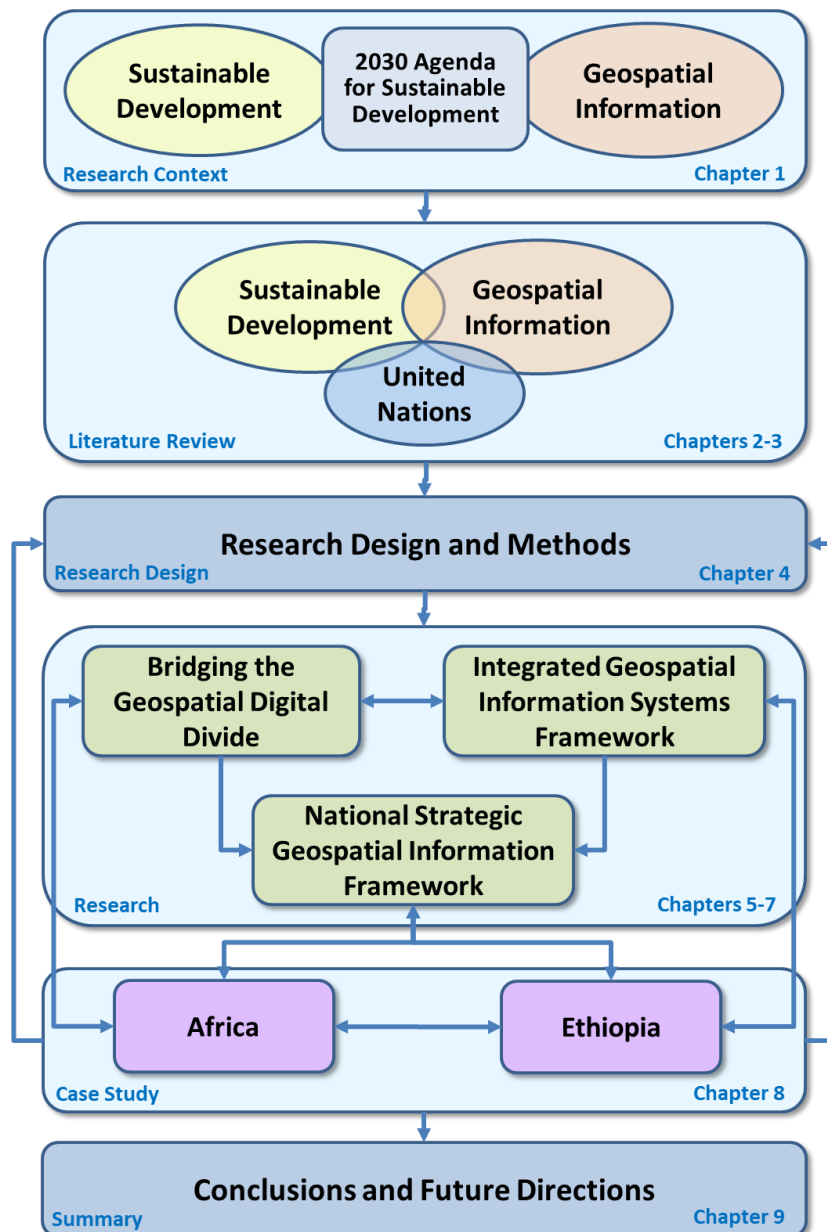


Figure 4.3: Structure and research design and approach for the dissertation.

In this process of review, it was recognised early that to capture the needs of developing countries, it was imperative to address systemic challenges to bridge the geospatial digital divide, and specifically the data needs of Africa, in determining the threshold with which to baseline the framework.

Therefore, the research is designed in such a way to implement mechanisms to bridge and overcome the geospatial digital divide and then develop an integrative sustainable development ‘data flow’ framework to provide the building blocks and processes for countries to measure and monitor the SDGs. Only then is it possible to develop and implement a new national strategic geospatial information framework.

In this process, the researcher approached and worked closely with the countries of Africa, through the national geospatial institutes and national mapping agencies, as represented by UN-GGIM Africa. With deductive analysis (from theory to data) the primary data was then collected and analysed against the theoretical framework to test the hypotheses. The primary data consists of detailed discussions and interviews with experts, through four interactive workshops conducted at regular intervals by the researcher in Africa from April 2018 to November 2019 (Chapter 8).

In addition, it was often necessary to clarify the data collected across a broader group of stakeholders to ensure that there was no bias in its collection and interpretation, as assumptions can be made when a single perspective is considered. In order to appropriately compensate, in developing the theoretical strategic framework, the researcher conducted nine further interactive discussions and workshops with a wide range of subject matter experts in more than 120 countries across the world, all with their own individual national circumstances and perspectives, to develop an all-encompassing framework that addresses the needs of a range of societal and technological starting points. These needs were not targeted at specific issues for specific countries. They were more general.

Given this breadth of coverage, many assumptions had to be made by the researcher. However, the volume of data being provided, and the multiple interactions with subject matter experts, assisted considerably in validating these assumptions to ensure the resultant data provided credible data and facts – and which could be aligned to global realities – such as the implementation of the SDGs, and thus, the applicability of the frameworks developed and advocated in this research.

Figure 4.3 illustrates the multiple inputs and ‘feedback’ loops that were applied in the process of developing and applying the framework. Given the process of iteratively developing the framework, these feedback loops proved to be immensely valuable. The consultations and workshops enabled the researcher to put forward a premise, the framework, examine the framework with the literature, test it by collecting appropriate data, validate it progressively over 18 months, prove the validity of the framework through a two-dimensional case study, and finally apply the framework.

4.8 Chapter Summary

This Chapter detailed the overall research strategy and design employed in this research. It described the adopted methodology in order to answer the research questions and achieve the desired research aim and objectives – the ‘research onion’ theoretical model developed by Saunders et al.

(2009). Saunders' research onion is a generic research procedure which helps depict issues underpinning the selection of data collection, research methods and a solution to the research problem. This research method allows several layers of research and considerations to be available and employed when conducting research. Anchored by Figure 4.1, the Chapter illustrated the contents of the six onion layers and elaborated each 'slice of the onion', starting from the outermost layer, described the research choices made, and justified the selection of the preferred methodology. The six different layers of the model represent the various stages through which the research must pass when putting together an effective methodology.

Having the research path clarified in this Chapter, the next Chapter discusses the implications of the digital divide that continues to exist today for developing countries and introduces and describes the 'geospatial digital divide' and the complex challenges that continue to exacerbate the ability for these countries to bridge this divide. For developing countries, realising digital transformation still remains completely out of reach, as they are yet to attain effective and sustained access to digital technology, the Internet and the corresponding computer literacy and skills that are needed to take part in the information society, to connect to the vast amounts of data and technology, and to orchestrate transformational change.

Chapter 5 – Bridging the Geospatial Digital Divide

5.1 Introduction

Mentioned briefly in Chapter 1, as the research evolved for this dissertation it became evident that the development and then implementation of a national strategic geospatial framework could not be achieved without considering and addressing the significant dependencies on geospatial data and emerging technologies, bridging the geospatial digital divide (especially in the African context), and an integrated geospatial information systems framework (Figure 1.2). These additional considerations were not originally planned. However, the adopted research design and methodology provided the flexibility to make the necessary adjustments. As noted by Bordens and Abbot (2008), research design is an essential instrument and fundamental structure to guide and give direction to research, enabling one to make decisions through the journey from an initial problem or a [set of] research question[s] to reach a suitable answer or solution for them.

In developing the conceptual framework, the researcher met with technical experts from more than 120 countries at a general level to gauge their geospatial understanding and needs. While not targeted at specific issues for specific countries, the needs of the developing countries, to bridge the ‘geospatial digital divide’, and for a more integrated geospatial information systems framework, were confirmed and validated. The dilemma for this researcher was that if these additional elements were not included now, then when would they, and by whom? Needless to say, these additional elements have been subsequently included in this dissertation in this Chapter 5 and Chapter 6.

In this regard, given the breadth and local to global dimensions and reach of the research problem and aim described in Chapter 1, and in considering the ensuing research questions (Section 1.2.2), one of the key objectives of this research was to investigate, evaluate and articulate the existence and implications of the geospatial digital divide in developing countries. Achievement of this objective ensures that the strategic framework is able to be used as a tool to improve understanding, address sustainable development data gaps, and assist developing countries in overcoming the digital and technological divide that continues to exist between the developed and developing world.

This Chapter addresses the ‘Bridging the Geospatial Digital Divide’ component of the dissertation as illustrated by Figure 1.2 in Chapter 1. The Chapter first reviews the relevance of the digital divide in sustainable development processes, then concepts of the ‘digital divide’ itself, especially the relevance to Africa as the home of the majority of LDCs, and as the implementation case study region for this dissertation. The Chapter then introduces and describes for the first time the ‘geospatial digital divide’ and the complex challenges that continue to exacerbate the ability for many developing countries to bridge this divide. For these countries, realising digital transformation remains completely out of reach, as they are yet to attain effective and sustained access to digital technology, the Internet and the corresponding computer literacy and skills that are needed to take part in the information society, to connect to the vast amounts of data and technology, and to orchestrate transformational change.

5.2 The Digital Divide, Sustainable Development and Africa

By its very nature and condition the digital divide is interconnected with the ambitions of achieving sustainable development, reducing the growing inequalities that exist in developing countries, and striving for national social, economic and environmental development and prosperity (ITU, 2018). Most, if not all of the SDGs, can be enabled or strongly supported by ICT, but stark digital divides, both between and within countries, are limiting their potential effect (Andreasson, 2015). These ambitions, and to bridge the digital divide, are intrinsically embedded into the development needs of Africa; a continent of 54 countries, 1.2 billion people, 20% of the Earth's land mass, and home to 33 of the world's 47 LDCs (UNECA, 2016a). As much of the following global commentary demonstrates, in terms of closing the gap in the digital divide in a new world of digital transformation, e-commerce and e-inclusion, Africa continues to be at risk of being marginalised and left behind in world development generally – and geospatial information development specifically.

5.2.1 Contextualising the 2030 Agenda

The 2030 Agenda emphasised its adoption at a time of immense challenges to sustainable development; that billions of the world's population continue to live in poverty, are denied a life of dignity, are subject to rising inequalities within and among countries, and that there are enormous disparities of opportunity, wealth and power (United Nations, 2015a). This was despite the successes of the MDGs, which helped to lift more than one billion people out of extreme poverty, to make inroads against hunger, to enable more girls to attend school than ever before and to protect our planet (United Nations, 2015c). However, the 2030 Agenda also emphasised that it is a time of immense opportunity and that significant progress has been made in meeting many development challenges. Within the past generation, hundreds of millions of people have emerged from extreme poverty, and access to education has greatly increased (United Nations, 2015a). Further, the spread of information and communications technology and global interconnectedness has great potential to accelerate human progress, to bridge the digital divide, to develop knowledge societies, and scientific and technological innovation (United Nations 2015a, para. 14-15).

While acknowledging the ambitious and global policy mandate of the 2030 Agenda, and the fundamental need to transform the world onto a sustainable and resilient path, a number of key questions remain to allow ambition and reality to be equally considered. Specifically, are the scales and dimensions of the enormous problems faced by developing countries, and the continent of Africa in particular, yet recognised and understood, let alone measurable? Do we know where they are, whom they impact, their causes and effects, how they can be remedied, appropriate interventions, and are they sustainable? These challenges bring into question if the aspirational ambitions of the 2030 Agenda, the *“great potential to accelerate human progress, to bridge the digital divide and to develop knowledge societies”* (United Nations, 2015a, para.15) are achievable, at least for the most marginalised, within the near-term. Given the complex development issues and rising inequality faced by the majority of

developing countries, the breadth and nature of the SDGs and their implementation, the unprecedented new data and associated analytical demands, the rapidly growing science and technology requirements, and the lack of awareness and understanding of the role of mapping and geospatial information science at national policy and decision-making levels...perhaps not.

This ‘rising inequality’ extends to the availability of even the most elementary maps, data, ICT, scientific and technological innovation, and global interconnectedness in order to communicate with, and transition to, knowledge and information societies. Billions of people are still excluded from the new world of data and information by circumstance; location, language, poverty, lack of education, lack of technology infrastructure, remoteness, or prejudice and discrimination. While the readily available technology, information and knowledge in the developed world provides almost unlimited choices, in the developing world many are still forced to make one choice – between food and knowledge. Such is the extent of the gap that remains to be closed in bridging the digital divide in the context of sustainable development (Scott and Rajabifard, 2019).

5.2.2 A World That Counts

In early 2014, the United Nations Secretary-General called for a data revolution in support of sustainable development, in anticipation that a sustainable flow of high-quality, timely, authoritative and accessible data will be needed for ongoing measurement of progress towards the then emerging SDGs. To generate this flow, a data revolution – a transformation of how data is produced and used to drive development – was seen as being critical (IEAG, 2014a). The Secretary-General established an Independent Expert Advisory Group on a Data Revolution for Sustainable Development (IEAG) to craft a strategic framework and advise the Secretary-General on what the “data revolution for development” would mean in practice (IEAG, 2014a).

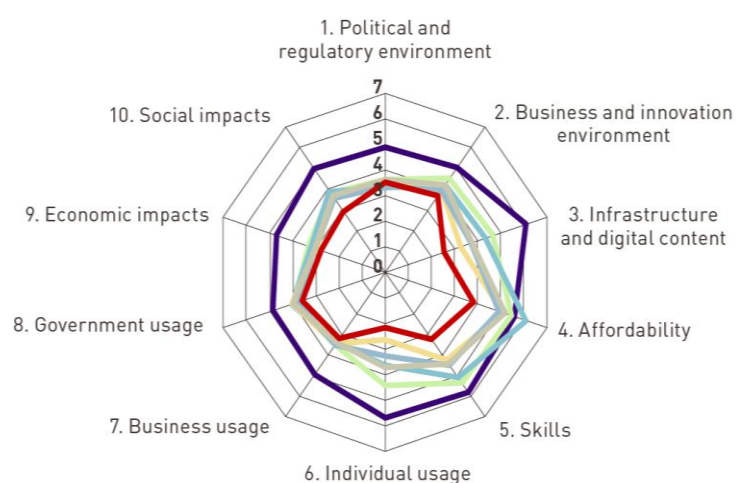
The resulting report *A World That Counts* calls on governments and the United Nations to act to “enable data to play its full role in the realisation of sustainable development by closing key gaps in access and use of data” between developed and developing countries, between information-rich and information-poor people, and between the private and public sectors (IEAG, 2014b, p.5). *A World That Counts* emphasised that data are the lifeblood of decision-making and the raw material for accountability, and that without high-quality data providing the right information on the right things at the right time; designing, monitoring and evaluating effective policies becomes almost impossible (IEAG, 2014b). Thanks to new technologies, the volume, level of detail, and speed of data available on societies, the economy and the environment is without precedent. This is the ‘data revolution’: the opportunity to improve the data that is essential for decision making, accountability and solving development challenges (IEAG, 2014b).

The report noted that while the advanced economies are already living in this new world of the data revolution, too many countries are excluded because of lack of resources, knowledge, capacity or

opportunity (Figure 5.1) (IEAG, 2014b). There are huge and growing inequalities in access to data and information and in the ability to use it, and that major gaps are already opening up between the data haves and have-nots. As can be seen in Figure 5.1, sub-Saharan Africa is notably behind in all indicators; individual usage, infrastructure and digital content being a major concern. Without action, a whole new inequality frontier will open up, splitting the world between those who know, and those who do not. Many people are excluded from the new world of data and information by language, poverty, lack of education, lack of technology infrastructure, remoteness or prejudice and discrimination. While the use of new technologies has exploded everywhere in the last ten years, the costs are still prohibitive for many (IAEG, 2014b).

INEQUALITIES IN ACCESS TO AND USE OF ICT SERVICES*

- Advanced economies
- Southern, Central and Eastern European Countries
- Commonwealth of Independent States and Mongolia
- Developing Asia
- Latin America and the Caribbean
- Middle East and North Africa
- Sub-Saharan Africa



* Regional score averages based on the Global Information Technology Report 2013, by the World Economic Forum

Figure 5.1: Advanced economies are ahead of the rest of the world on almost every indicator of access to and use of digital technologies. Sub-Saharan Africa is notably behind in all indicators (IEAG, 2014b).

5.2.3 The Millennium Development Goals Report 2015

The final *Millennium Development Goals Report* (United Nations, 2015c) summarised fifteen years of concerted effort and significant progress in lifting more than one billion people out of extreme poverty. The Report also provided an opportunity to reflect on some of the important shortfalls encountered and numerous lessons learned as the world tried to achieve the eight aspirational goals. The major lesson – data are an indispensable element of the development agenda (United Nations, 2015c). Despite significant and recognised global achievements and many successes the MDGs failed to recognise the need for data and geography, and were limited in their ability to track and monitor progress consistently. In essence, there was no sustainable data to measure and monitor sustainable development and the poorest and most vulnerable people are being left behind (Scott and Rajabifard, 2017).

Under Goal 8: Develop a global partnership for development, and Target 8.F, the MDG Report noted that while mobile-cellular and Internet penetration rates have grown strongly, the digital divide

between the rich and the poor is growing. The digital divide is particularly pronounced with respect to Internet use and quality of access. For instance, just over one third of the population in developing countries uses the Internet, compared to 82% in developed countries. The contrast is even more dramatic in sub-Saharan Africa, where less than 21% of the population uses the Internet, and in the LDCs the number is less than 10% (Figure 5.2) (United Nations, 2015c).

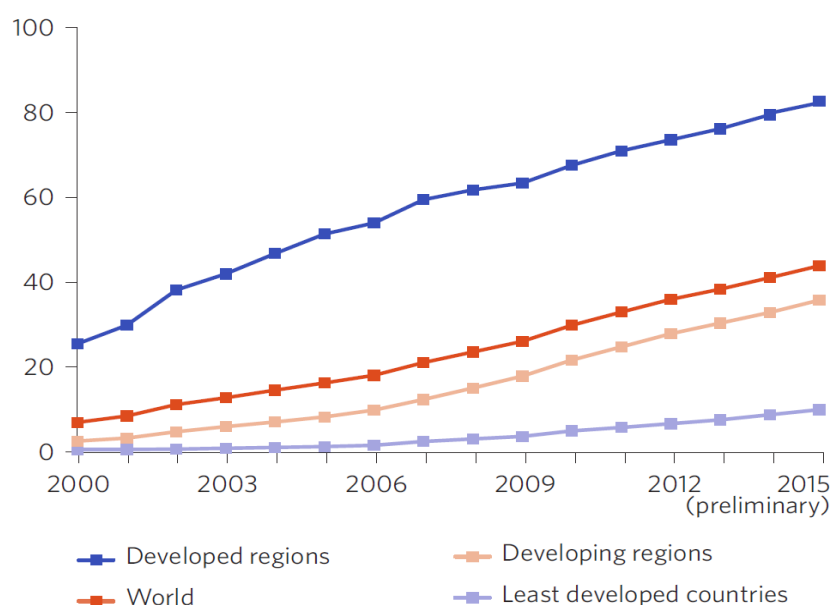


Figure 5.2: Number of Internet users per 100 inhabitants, 2000-2015 (United Nations, 2015c).

Although Internet bandwidth and national backbone capacities are important building blocks for providing affordable high-speed Internet access, they remain a major challenge in many developing countries, particularly small island and landlocked developing States (United Nations, 2015c). There are also major inequalities across countries in terms of costs of ICT services, availability of ICT skills and availability of relevant and local content. Issues essential to address the widening digital divide. Only then will the transformative power of ICTs and the data revolution be harnessed to deliver sustainable development for all (United Nations, 2015c).

5.2.4 Addis Ababa Action Agenda on Financing for Development

The *Addis Ababa Action Agenda on Financing for Development* (United Nations, 2015e) recognises the importance of addressing the diverse needs and challenges faced by countries in special situations, in particular African countries, LDCs, landlocked developing countries and SIDS (referred to collectively as countries in special situations). As an outcome document determined in Africa, it particularly recognises the need to achieve a positive socio-economic transformation in Africa through science, technology, innovation and capacity building.

The Action Agenda recognises that the creation, development and diffusion of new innovations and technologies and associated know-how, including the transfer of technology on mutually agreed terms, are powerful drivers of economic growth and sustainable development. However, it notes with

concern the persistent ‘digital divide’ and the uneven innovative capacity, connectivity and access to technology, including ICTs, within and between countries (United Nations, 2015e). The need to promote the development and use of ICT infrastructure, as well as capacity-building, particularly in countries in special situations, including rapid universal and affordable access to the Internet, was stated (United Nations, 2015e, Para. 114).

With regard to data more broadly for the SDGs, the Action Agenda noted that data access alone is not enough to fully realise the potential that data can offer to both achieving, monitoring and reviewing the SDGs (United Nations, 2015e). Countries should endeavour to ensure broad access to the tools necessary to turn data into useful, actionable information; and support efforts to make data standards interoperable, allowing data from different sources to be more easily compared and used. The objective being to achieve a significant increase in global data literacy, accessibility and use, in support of the development agenda. (United Nations, 2015e, Para. 114).

5.2.5 The Sustainable Development Goals Report 2017

The *Sustainable Development Goals Report 2017* reviews progress made towards the 17 SDGs in the second year of implementation of the 2030 Agenda (United Nations, 2017a). While providing a snapshot of our global efforts to date, it stresses that high-level political leadership and new partnerships will be essential for sustaining momentum. It also underscores the need for reliable, timely, accessible and disaggregated data to measure progress, inform decision-making and ensure that everyone is counted (United Nations, 2017a). As articulated in the global indicator framework, indicator 9.c under Goal 9 of the SDGs (Industry, Innovation and Infrastructure), requires that countries are able to significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in LDCs by 2020 (United Nations, 2017a).

Under Goal 17: Partnerships for the Goals, the Report notes that Internet services remain inaccessible across large swaths of the developing world. Fixed-broadband services remain largely unaffordable and unavailable across large segments of the developing world. As shown in Figure 5.3, in 2016 fixed-broadband penetration reached 30% in developed countries, but only 8.2% and 0.8% in developing regions and LDCs, respectively. In the developed regions, about 80% of the population are online, compared to 40% in developing regions and 15% in LDCs (United Nations, 2017a).

Although Internet use in LDCs has tripled over the last five years, the percentage of users today only reaches the level enjoyed by developed countries in 1998. However, the LDC average hides large disparities, with some countries doing much better than others. In 2016, levels of Internet use worldwide were 12% lower for women than for men; the gender gap remains even larger in LDCs at 31%. Both globally and in LDCs, this gender gap has widened in recent years (United Nations, 2017a).

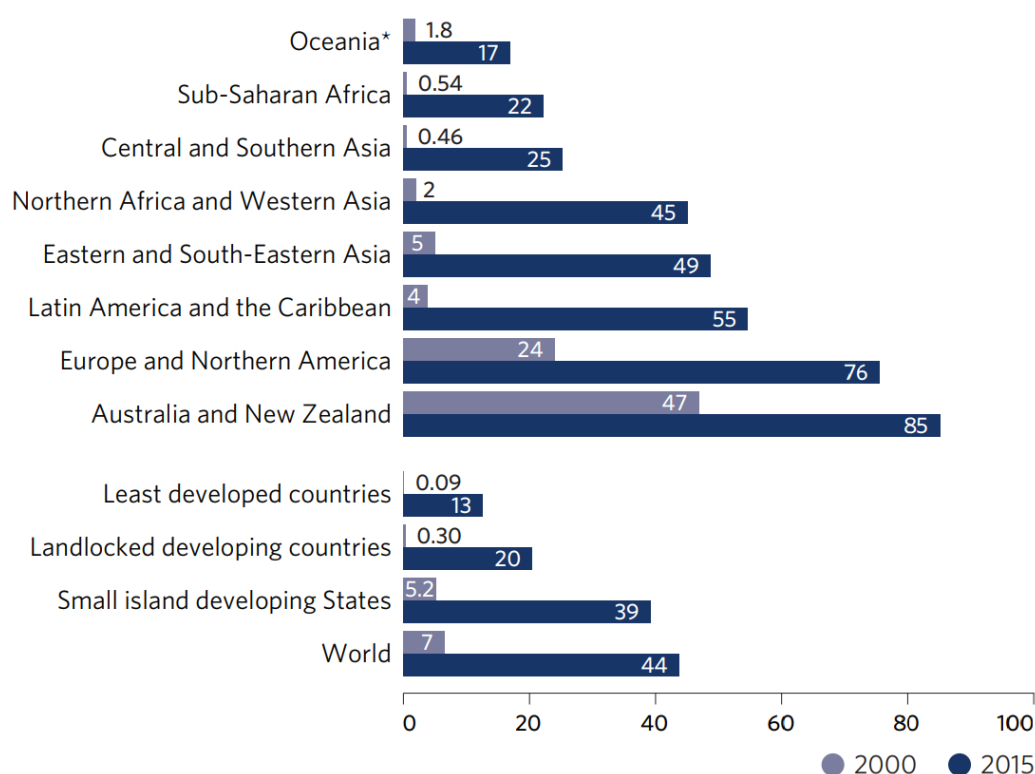


Figure 5.3: Individuals using the Internet, 2000 and 2015 (percentage) (United Nations, 2017a).

5.2.6 World Economic and Social Survey 2018

Launched in October 2018 by the United Nations, *The World Economic and Social Survey 2018: Frontier technologies for sustainable development* (United Nations, 2018c), reviews the advances in frontier technologies – automation, robotics, electric vehicles, renewable energy technologies, biotechnologies and artificial intelligence – and analyses their economic, social and environmental impact. While these innovative and rapidly growing technologies possess immense potential for fostering growth, prosperity and environmental sustainability and accelerating the achievement of the 2030 Agenda, advances in frontier technologies also present new and unique challenges (United Nations, 2018c). While promising prosperity, when left unmanaged or mismanaged, new technologies will likely widen inequality within and between countries. Artificial intelligence, machine learning, and robotics automation, among other technologies, can enhance economic efficiency but at the same time create winners and losers; presenting risks of growing unemployment, under-employment and inequality, and raise new ethical and moral challenges. Many may be left behind or displaced by technological change (United Nations, 2018c).

In this regard, the Survey considers the challenges to closing the technological gap to bridge the development divide. While developed countries are able to seize upon the opportunities associated with frontier technologies, many developing countries are yet to fully reap the benefits of existing technologies. A great technological gap persists, largely explaining the “development divide” between

developed and developing countries. More than 1 billion people in the developing countries still do not have access to electricity, and an additional 2.5 billion are “under-electrified”, experiencing weak connections and frequent power outages. The millions who still depend on human or animal muscle power for cultivation and other forms of production remain shackled to technologies from the pre-industrial era (United Nations, 2018c). They also lack access to modern education and health systems, which are crucial for accumulation of a threshold level of human capital needed for the adoption of many frontier technologies. Creating enabling conditions and bridging the technology divide will remain a key development strategy for many developing countries (United Nations, 2018c).

5.2.7 The Sustainable Development Goals Report 2019

In the *Sustainable Development Goals Report 2019* (United Nations, 2019a), providing a snapshot of our fourth year of implementation of the SDGs, the Secretary-General of the United Nations noted that it is abundantly clear that a much deeper, faster and more ambitious response is needed to unleash the social and economic transformation needed to achieve our 2030 goals. Support for implementing the SDGs is gaining momentum, but major challenges remain (United Nations, 2019a).

The Report highlights areas that can drive progress across all 17 SDGs: financing; resilience; sustainable and inclusive economies; more effective institutions; local action; better use of data; and harnessing science, technology and innovation with a greater focus on digital transformation. It confirmed that the Internet can be a gateway to development, and a means of implementation for many of the SDGs. However, while a growing share of the global population has access to the Internet, and a Technology Bank for LDCs has been established, the digital divide persists (United Nations, 2019a).

At the end of 2018 more than half the world’s population (3.9 billion people) used the Internet – an important step towards a more inclusive global information society. As shown in Figure 5.4, over 80% of people in developed countries were online in 2018, but this compares with 45% in developing countries, and only 20% in LDCs (United Nations, 2019a). Access to broadband networks is believed to have a significant impact on global economic output. An increase of 1% in fixed broadband penetration – the number of subscriptions per 100 inhabitants – is associated with a rise of 0.08% in global GDP, on average. The impact is higher in developed countries than in developing countries. Globally, growth in fixed broadband subscriptions has been sustained, with the penetration rate rising from 3.4 per 100 inhabitants in 2005 to 14.1 in 2018 (United Nations, 2019a).

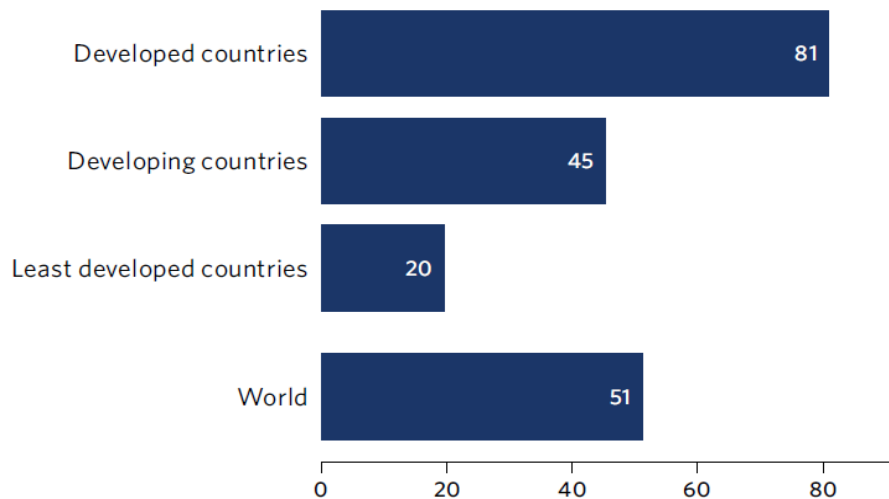


Figure 5.4: Proportion of population using the Internet, by country groupings and globally, 2018 (percentage) (United Nations, 2019a).

5.3 Concepts of the Digital Divide

The first general concepts of the digital divide emerged in the 1980s, initially with reference to the unequal access to computers, and then more so in the early 1990s with the advent of the Internet and other forms of communication technology. The term ‘digital divide’ came into more regular usage in the mid-1990s to describe the gap between those who have – and those who do not have – access to computers, the Internet and the corresponding computer literacy (Hayward, 1995; Leidig and Teeuw, 2015). Other terms used to describe that disparity included; information inequality, information gap or knowledge gap, and computer or media literacy (Van Dijk, 2006). While the digital divide terminology has often caused more confusion than clarification (Van Dijk, 2006), it has also been used in order to fit the needs of the message of the day, is a dynamic concept that has evolved over time, and has changed with technology (ITU, 2017) and the associated technological opportunity. The great merit of the sudden rise of the term ‘digital divide’ at the turn of the century is that it put the important issue of inequality in the information society on the scholarly and political agenda (Van Dijk, 2009).

By the late 1990’s, ICT was seen as *the* potential tool to help the developing world scramble out of its current state of impoverishment as was chiefly featured in the MDGs (Ranganathan, 2011). Terms like ‘bridging the digital divide’ and ICT4D (information and communication technologies for development) became popular topics of discourse, leading to a whole gamut of initiatives both by governments in developing nations, world-wide organisations like the World Bank, the United Nations and other non-government enterprises (Ranganathan, 2011).

In 2001, the Organisation for Economic Co-operation and Development (OECD) summarised the digital divide as the gap between individuals, households, businesses and geographic areas at different socio-economic levels with regard both to their opportunities to access modern ICTs and to their use of the Internet for a wide variety of activities (OECD, 2001). The technologies can include the

telephone, television, personal computers and the Internet, particularly for education and being able to conduct business in an increasingly and more globally interconnected world. The digital divide reflects various differences among and within countries (OECD, 2001). The digital divide also arises from the increase in innovation and use of technologies. It refers to the gap between demographics that have access to the newest and most innovative technologies and those who do not. An especially relevant example is the advent of, and access to, mobile phones and smartphones over the past decade. These demographics that do not have access to ICTs, including the related skills that are needed to take part in the information society, do not have the same opportunities and resources to advance their communities and solve societal problems (OECD, 2001).

The digital divide also represents the differences in economic class, and can be classified according to criteria that describe the difference in participation according to gender, age, education, income, social groups, or geographic location (EuroStat, 2005). Gunkel (2003) and Van Dijk (2003, 2005) have emphasised that the term echoes some kind of technological determinism. It is often suggested that the origins of the inequalities referred to lie in the specific problems of getting physical access to digital technology and that achieving such access for all would solve particular economic and societal problems (Gunkel, 2003 and Van Dijk, 2003, 2005). Andreasson (2015) defines the digital divide broadly as the access, skills, and capacity to take advantage of ICTs in order to reap the full benefits of the information society.

The New World Encyclopedia (2018) suggests that the digital divide refers to the gap between people with effective access to digital and information technology and those with very limited or no access at all. It includes the imbalances in physical access to technology as well as the imbalances in resources and skills needed to effectively participate as a digital citizen. In other words, it is the unequal access by some members of society to ICTs, and the unequal acquisition of related skills. Further, the New World Encyclopedia (2018) suggests that another key dimension of the digital divide is the global digital divide, reflecting existing economic divisions in the world through the differences in technology access between countries or regions. For example, countries with a wide availability of Internet access can advance their economies on a local and global scale considerably more diversely and rapidly than those that do not have such wide access. In today's society, jobs, education, and careers, and hence, socio-economic prosperity, are directly related to the Internet, in that the advantages that come from the Internet are so significant that neglecting them would leave a country vulnerable in a changing market (New World Encyclopedia, 2018).

Increasingly, the digital divide is taking on more relevance as new 'digital' topics and paradigms emerge – including digital transformation, disruptive technologies, the Fourth Industrial Revolution, etc. as discussed in Chapter 3, Section 3.6 – which enable technological progress and affordability (especially through mobile phones) to greatly improve access to digital and information technology. However, as the opportunities to participate in the information society increase, so do the

consequences for those who are not able to take advantage of them (Andreasson, 2015). Hernandez and Roberts (2018) argue that in an increasingly digital world, relatively privileged people are able to use their access to mobile and internet technologies to access clear *digital dividends* including remote access to health and education information, financial inclusion and digital pathways to economic and political empowerment. However, already disadvantaged people have less access, agency and ability to reap these digital dividends, and are being left further and further behind. They suggest that the digital divide is not binary, that new classes of technology access and connectivity experience are leading to a range of different digital inclusions and exclusions, and that existing (dis)advantage is being amplified (Hernandez and Roberts, 2018). For example, marginalised and vulnerable groups are least able to afford or apply the latest technology or highest connectivity speeds. As governments and industry move more of their services and initiatives online, the unconnected and the least connected are being left further behind. Avoiding this requires a reorientation of digital development to *put the last first* so that the use of digital technology does not amplify both dividends and divides (Hernandez and Roberts, 2018).

The use of digital technology and digital transformation brings with it an additional dimension for the digital divide. Toyama (2011) argues convincingly that technology has no transformative capacity in and of itself, and that technology use can only amplify existing human capacity and intent: it cannot act as a substitute where human capacity and intent do not exist. Even if differential access to technology could be countered through a universal allocation of technology, disparities among people, such as better education, refined social skills, and influential connections all translate to a greater ability for the better-off to use technology for their own purposes. The greater one's skills and capacities, the more value technology has (Toyama, 2011).

According to Andreasson (2015), new divides are emerging as quickly as the development of technology. As some gaps are narrowing, such as basic access to mobile phones, which are near saturation level in many countries, others are widening, such as the speed and quality of those devices. The notion that there is a digital divide, either between those who have access and those who don't or between developed economies and emerging markets is an understatement of the complexities underpinning the challenges ahead. In essence, many countries face the same digital divide challenges, yet prioritise them differently depending on context and local variations (Andreasson, 2015). The United Nations (2018d) suggests that the debate has moved from a digital divide to 'multiple' digital divides, which are not only a global challenge but also local contextualised problems in terms of availability of content, bandwidth, and skills, among other issues. Figure 5.5 provides valuable insights to these digital divides.

Divide	Description
Access	It starts with access or the lack thereof. Although Internet penetration has increased, it continues to be a key barrier as more people globally remain offline rather than online.
Age	Older people are generally using ICTs to a lesser extent than younger populations, despite the notion that they could benefit from online social and health services.
Bandwidth	International bandwidth and the capacity to transmit and receive information over networks vary greatly between countries, but also within them, limiting potential useful endeavors.
Content	The creation and consumption of local content are important as useful usage can depend on context and language.
Disability	Those with disabilities face additional hurdles to use ICTs, although this can also be turned into a potential e-inclusion opportunity by increasing digital accessibility.
Education	Like social divides, education and literacy rates are fundamental challenges to bridge digital divides.
Gender	There is a small but persistent difference in online usage between men and women.
Immigration	Migrants may not possess the same levels of digital skills as the population in their new country and, if they do, may be subject to content and language divides.
Income	The gap between rich and poor affects affordability of ICTs, but also usage patterns and is as important within countries as much as between them.
Location	Rural and remote areas are often at a disadvantage in terms of speed and quality of services as compared to their urban counterparts.
Measurement	There is a divide in measuring progress between countries, within them, and also in the evaluation of specific development projects.
Mobile	Mobile devices provide opportunities to bridge the access gap, but can also introduce new forms of divides in terms of technology, speed, and usage.
Speed	The gap between basic and broadband access is creating a new divide as speed is important to reap the full benefits of a digital society.
Useful usage	What people do with their access or “useful usage” is a key divide in using ICTs productively according to their abilities.

Note: Intended to be illustrative, not exhaustive.

Figure 5.5: Selection of digital divides, from access to useful usage (Andreasson, 2015).

5.3.1 The Digital Divide

In general, the digital divide reflects the ‘gap’ between those that have access to the newest and most innovative ICTs and those that do not (Abramson, 2006). Due to the range of criteria which can be used to assess the imbalance and gap, and the lack of detailed data on some aspects of technology usage and how much ‘access’ is able to be translated into productivity, the exact nature of the digital divide remains both contextual and debatable (New World Encyclopedia, 2018). However, there is overwhelming evidence it exists, and more so in some regions than others – and Africa being the most obvious example.

Criteria often used to distinguish the gaps between the 'haves' and the 'have nots' of the digital divide tend to focus on access to hardware, access to the Internet, and details relating to both categories (IAEG, 2014b). But, as shown in Figure 5.6, there are multiple layers of additional, and non-linear, criteria to consider. Expanding on the concept of ‘gap’ as reflected in the literature, the first and inner layer is the ‘Digital Access Gap’, the core of the digital divide. The access gap captures the primary, and most basic, enabling mechanisms for overcoming the digital divide – an individual's and nation's ability to have access to and take advantage of computers, ICTs and the Internet.

This digital access requires having both physical access to an Internet-enabled computer or device, and the material assets for sustained connection to the Internet, including suitable bandwidth and the ongoing costs of certain subscriptions and the necessary peripherals for use. Although many developing countries may already have the basic infrastructure to connect to the global information network, affordable and equitable access is still a critical issue (Zaied, 2008).

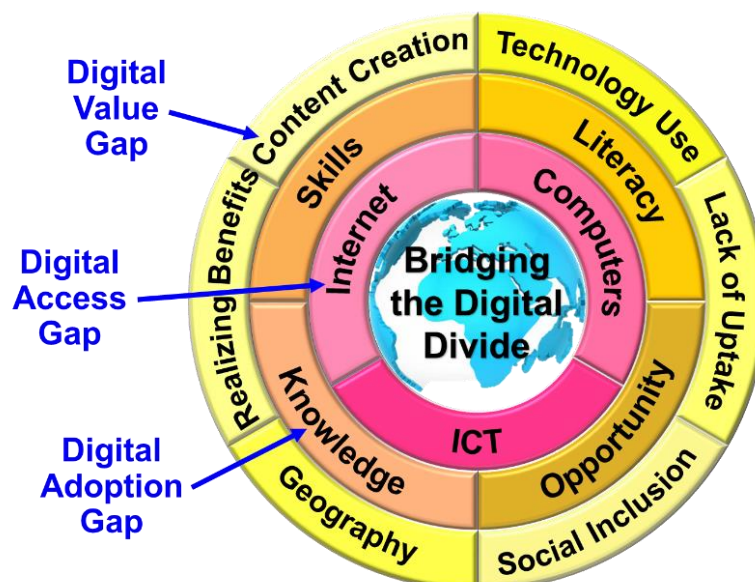


Figure 5.6: The multiple and non-linear layers of criteria and gaps between the 'haves' and the 'have nots' of the digital divide.

Ironically, for regions such as Africa, another key and influencing determinant not often considered is access to reliable electricity, the backbone of any modern economy, without which there simply is no access to computers, ICTs and the Internet, and enjoyment of the subsequent opportunities and benefits. Access to electricity in Africa is increasing, albeit unevenly across the continent's sub-regions. In 2016, about 657 million people in Africa – about 53% of the continent's approximately 1.2 billion people – had access to electricity (UNECA, 2018). Even today, the rate of access to electricity in sub-Saharan Africa is only 43%, the lowest of all world regions (the global access rate is 87%), but the total number of people without reliable electricity has increased in recent decades as population growth has outpaced growth in electrification (Blimpo and Cosgrove-Davies, 2019; UNECA, 2018).

The second layer, the 'Digital Adoption Gap', relates to users having the 'opportunity' to participate in the information society (Rogers, 2003). Possessing the necessary skills, knowledge and literacy to adopt and make use of ICT, computers and the Internet. The digital divide is also a human skills and knowledge transfer divide – stemming from a lack of basic education, training and awareness. In many instances, the lack of such skills is related to digital and Internet literacy and not only exists between countries, but also within countries where segments of society have different knowledge, education, opportunities and experiences of digital technology and its adoption. Also, many developing countries do not have the legal frameworks and institutional capacities to foster widespread adoption and absorption of ICT, or to attract the relevant national and international investment for infrastructure, enterprise, services and capacity development (UNDP, 2001). That said, the mass penetration of mobile devices in the developing world, particularly by the younger generations, is gradually closing this adoption gap.

The third layer is the 'Digital Value Gap' and is governed by the lack of uptake, benefits and realisation of the value in creating content and using the available technology, as well as how and for what purposes. This can be viewed as a gradation of inclusion (or exclusion), which can be mapped along the intersections of gender, race, ethnicity, age, education, socio-economic class (social inclusion), and geography. With respect to geography, these societal elements can be mapped further when aspects such as rural versus urban and industrialised versus developing countries have an effect. Additionally, the broader overarching national social, political, and economic implications of the digital divide for countries, including lack of opportunity to solve societal problems, should be considered in the Digital Value Gap (Bozeman, 2007; Moore, 1995).

In situations where the Internet has recently, and quickly, reached many developing countries, the intensity of use is lower in less technologically advanced developing countries, owing partly to a large within-country digital divide in many of those countries. For example, there are important gaps in access to Internet between men and women, urban and rural areas, and the young and old (United Nations, 2018a, 2018c). Special attention also needs to be paid to vulnerable groups as there is a strong

correlation between digital exclusion and social exclusion. One explanation for the between- and within-country divides is that effective use of the Internet is a function of literacy. While greater attention needs to be paid to digital literacy among the population at large, closing the digital divide points to the need to focus on basic primary and secondary education and digital literacy (United Nations, 2018a, 2018c).

Importantly, there remains a need to bring people online in the first instance. In some cases, this remains a problem due to lack of access to ICT infrastructure. Governments must raise awareness of the value of online services to motivate usage. In this effort, relevant and sufficient content should be provided in local language and at local levels (United Nations, 2018c).

5.4 The Geospatial Digital Divide

The previous sections outline and discuss the gaps in the digital divide and their closely coupled relationship with the ambitions, and related expectations of achieving sustainable development, and that the aspirations to bridge the digital divide are intrinsically embedded into global development policy. The 2030 Agenda inherently recognises that the spread of ICT and global interconnectedness has great potential to accelerate human progress, to bridge the digital divide, to develop knowledge societies, and to increase scientific and technological innovation (United Nations, 2015a, para. 15). Realising this potential and implementing the SDGs will require addressing and closing the access, adoption and value gaps of the digital divide which, in Africa and the LDCs, is arguably growing not reducing.

A more complex dimension to bridging the digital divide immediately emerges when countries are required to exploit the contribution to be made by geospatial information and Earth observations to measure and monitor the ‘geographic location’ characteristics of the SDGs, targets and global indicators (United Nations 2015a, Goal 17.18). Although today’s technology makes it possible to acquire and collate the data needed to keep the promise to leave no one behind, the challenges faced in the collection, processing, analysis and dissemination of reliable, timely, accessible and sufficiently disaggregated data for better evidence-based policymaking are still considerable (United Nations, 2018a). The provision and exploitation of the new mapping and geospatial data needs, information systems, analytics and associated enabling tools and technologies, many of which are becoming more web-dependent, to support the implementation of the SDGs is not yet occurring by default. An urgent transformational change in both thinking and approach is required – a digital transformation – which is simple in theory, but complex in implementation.

Geospatial information technologies, like many technological developments, are now more increasingly integrated with ICT, the Internet, and other enabling technology elements, in transforming data and organisational workflows (Masser, 2005b). However, the lack of robust ICTs, including internet services and bandwidth, and the related geospatial data and emerging technologies to support national data and information systems in developing countries, compound these vulnerabilities.

Therefore, successfully implementing the 2030 Agenda is inherently dependent on countries being able to first bridge the digital divide before they can adequately exploit the capabilities of geospatial information and associated technologies – and achieve digital transformation.

However, for even the most developed countries, achieving digital transformation is being exacerbated by the lack of awareness and understanding of the role of geospatial information at the policy and decision-making levels. For developing countries, realising any digital transformation still remains completely out of reach, as they are yet to even attain effective and sustained access to digital technology, the Internet and the corresponding computer literacy and skills that are needed to take part in the information society and to orchestrate transformational change. They are yet to bridge the ‘digital divide’ before contemplating increased awareness and understanding of geospatial information, NSDIs, and sustainable national mapping.

Meeting the new and comprehensive data requirements of the SDGs is already proving difficult for some of the most advanced countries, but the 2030 Agenda further demands that by 2020 this enhanced data availability is able to support and address the capacities of countries in special situations. The very countries that have yet to adequately bridge the digital divide. Additionally, while the most developed countries are grappling with an abundance and oversupply of data and associated enabling technologies, the opposite applies in many parts of the developing world, where data and technology scarcity still prevails. When applied specifically to addressing sustainable development challenges, there is a greater concern. Those countries that are experiencing significant geospatial data, technology and capacity scarcity are also the most vulnerable and at greatest risk of being left behind in the battle to achieve sustainable development.

5.4.1 Defining the Geospatial Digital Divide

The dilemma of bridging the multiple layers of criteria and gaps between the haves and the have nots of the digital divide (Figure 5.6) and to specifically meet the needs of the SDGs, is that there is a need to extend well beyond just having access to computers, the Internet and new and innovative ICTs, and connecting the unconnected. It will need to extend to bridging the ‘geospatial digital divide’, connecting to the vast amounts of data, including geospatial information, and scientific and technological innovation to measure and monitor the ‘geographic location’ characteristics of the SDGs, targets and global indicators.

Inspiration for this concept, that of a geospatial digital divide, ironically dates back to some of the early days of SDI development, and the works of Williamson et al. (2003). At that time it was understood that, while ICT forms the backbone of modern society, geospatial information provides the location dimension, both of which support the systems to allow modern societies to operate and allow both the natural and built environment to be modelled, understood and managed in a ‘complex digital environment’ (Williamson et al., 2003).

The geospatial digital divide is an extension of the digital divide, in which the lack of enabling mechanisms, such as ICT and Internet capabilities and access, are compounded and exponentially complicated by a lack of geospatial data and related enabling technology capability and capacity. Building directly upon the criteria and gaps of the digital divide in Figure 5.6, there are a number of critical ‘gaps’ contained within an additional three layers that contribute to the ‘geospatial’ dimensions of the digital divide as detailed in Figure 5.7.

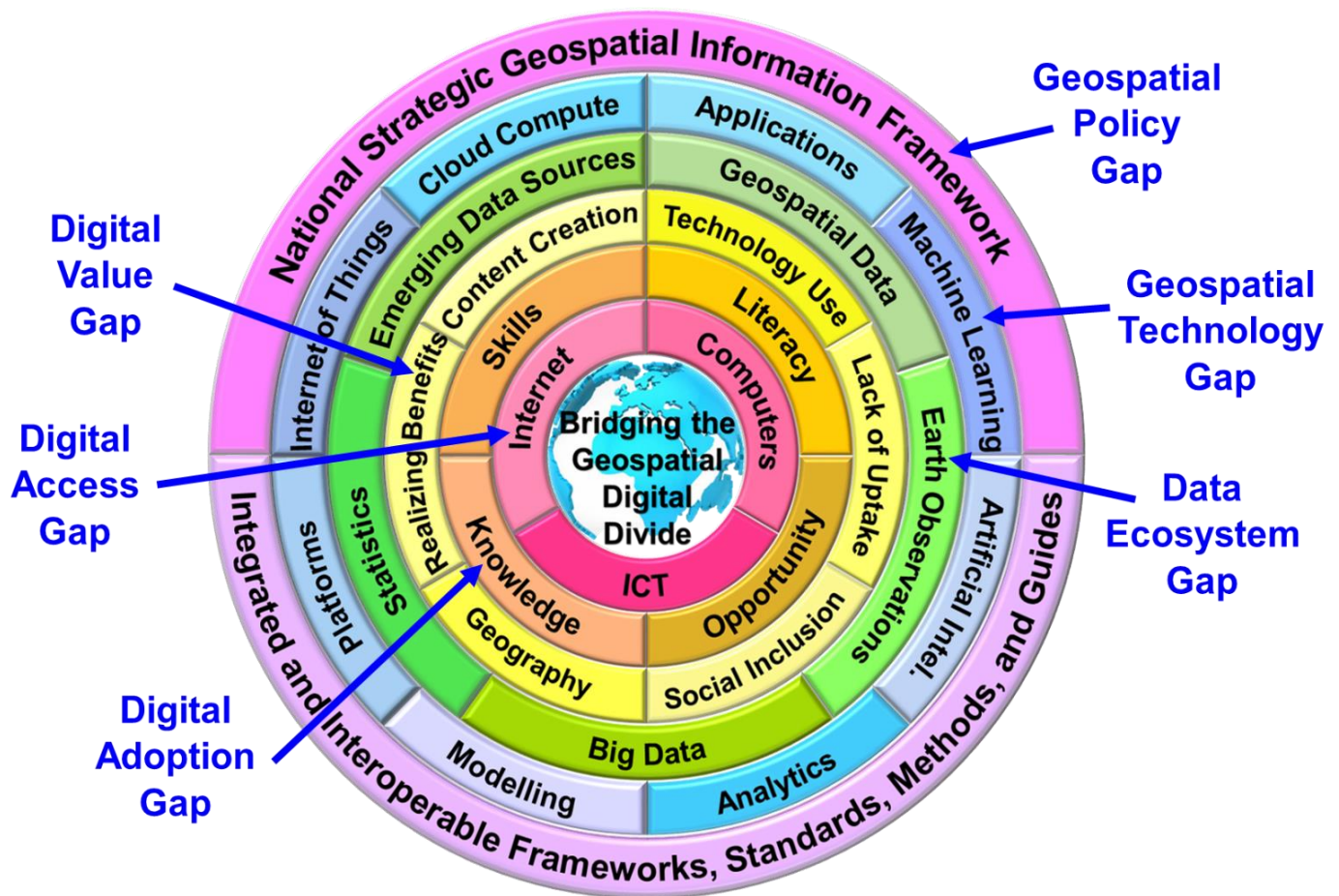


Figure 5.7: Building upon the criteria and gaps of the digital divide, there are a number of critical ‘gaps’ contained within an additional three layers that contribute to the ‘geospatial’ dimensions of the digital divide.

5.4.1.1 Data Ecosystem Gap

The ‘Data Ecosystem Gap’ is the fourth layer, and relates to the access to, and exploitation of, data itself – the vast amounts of geospatial data, Earth observations, statistics (population, socio-economic and environmental), Big Data and the many new and emerging data sources. Due to their multi-dimensional nature and breadth, and the associated unprecedented data demands, monitoring of and reporting progress on the SDGs will require significant improvements in supporting national data and information systems within countries. There is a rapidly growing realisation that implementing the SDGs, and measuring and monitoring their progress, will require new and large amounts of data, more

rigorous modelling and analysis, and much better data management. It is important that the goals, targets and indicators of the SDGs are able to be consistently tracked over long periods of time at varying scales, and that comparability across nations can be achieved, including through to globally harmonising national data. The location element of data, including statistical data, will be a critical consideration. Linking different data – demographic, statistical, Earth observations, environmental, Big Data, and other societal geospatial data – together with the one thing they have in common, to geographic location, will be key.

Much of the traditional ‘fundamental data’ would ideally reside within national information systems that exist within countries, providing the means to ensure access to high quality, timely and reliable data that are structured, organised and managed, ideally in an interoperable and standards-based manner. There are also many local to global data that reside outside these more formal systems – a broader ecosystem that includes additional data contributors from local and regional governments, private companies, academia, civil society, and citizens, including crowd-sourced and volunteer geographic information.

While geospatial information is the original Big Data, with data from multiple sources and acquisition platforms having been used over long time-space processes, today’s geospatial technologies are further able to gather, integrate and manage large volumes of both structured and unstructured data in a standardised and interoperable way from many sources. One of the strengths of the modern and lightweight geospatial data ecosystem is its ability to provide end-to-end solutions using Big Data, the Cloud, and computational modelling and analytics, and seamlessly integrated with Internet technologies. Yet, all of these virtues for geospatial enablement are actually the very impediments for developing countries, and for bridging the geospatial digital divide.

The ability to access online data, information and resources, as well as the ability to share and disseminate digital data and information, provides countries with the much needed global interconnectedness in order to communicate with and transition to knowledge and information societies. Geospatial information technologies can enable critical information to reach marginalised communities at a rate and scale never before possible. But for many, data remains a luxury and often agonisingly out of reach, even on mobile devices. This is increasingly being recognised in sustainable development. The challenge is how to transfer all of this technology and data richness, availability and connectivity to the technology and data poor.

In terms of a ‘data flow’ ecosystem for the SDGs, Chapter 6 introduces and defines a general integrative sustainable development data flow framework for a nationally integrated geospatial information system. Comprising a mix of national data, it provides the building blocks and processes for any given country to measure and monitor the SDGs from local real-world conditions to global harmonised reporting through robust and reliable data inputs. This framework recognises that the future

role of the NSDI should be as a ‘knowledge infrastructure’ that can be used for data integration, analysis, modelling, aggregation, fusion, communication, and for organising and delivering data across disciplines and organisations. The NSDI of the future, fuelled by high quality, timely and reliable fundamental geospatial data, can provide the means to organise and deliver core geographies for many national outcomes – including sustainable development.

5.4.1.2 Geospatial Technology Gap

The fifth layer, the ‘Geospatial Technology Gap’, relates to the enabling, and increasingly growing, technology innovations and digital transformation that influence what can be achieved with the geospatial data ecosystem and how to manipulate its end-to-end use during its life-cycle. These include innovations like Cloud storage and computing, the IoT, AI and robotics, and machine learning; and delivery platforms, hardware, software, applications and interfaces that enable robust and repeatable modelling and analytics.

These digital transformation potential and technology innovations in the geospatial information sector are also becoming major industry disruptors. As reported by Geospatial Media (2018) in the *2018 Geospatial Industry Outlook and Readiness Index*, the geospatial sector is becoming more aligned with a number of mainstream industry markets, providing the much-needed spatial dimension and location context to the emerging digital infrastructure, interconnected systems and business process. The last five years in particular has seen a paradigm shift in the geospatial market, with technology innovations like the Cloud, the IoT, Big Data and AI playing multiplier roles in expanding the industry and bringing significant attention from the mainstream ICT and engineering markets (Geospatial Media, 2018). Digital transformation and geospatial information technologies and processes, from satellite sensors through to geospatial Cloud services to smartphone applications, can give governments, businesses, communities and citizens an opportunity to improve efficiency and encourage innovation.

These major innovations are being ably supported by others such as unmanned aerial systems, Blockchain, precise positioning (to support autonomous vehicles), mobile devices and the saturation of location-based applications and services. This has created demand for geospatial content and solutions across governments, businesses and consumers, and to the world economy and society (Geospatial Media, 2018). Of note is the observation that geospatial technologies are capable of establishing interactions and interlinkages between the bio-physical (geography and natural resources) and societal elements (people and place) over time and space, and holds the key to the efficient delivery of socio-economic benefits within and across national economies. These technology enablers, or digital ‘fabrication’ technologies are fundamentally altering the way geospatial information is being used and delivered in the emerging data ecosystem (Geospatial Media, 2018).

Geospatial Media (2018) note that the downside of the technology innovation trend is that the lack of robust digital infrastructure, including Internet connectivity and ICT infrastructure, are major

limiting factors to the proliferation of digital, location-enabled services and business models. *“While many countries have made significant progress in building digital infrastructure with improved coverage and quality in the recent past, most of the developing economies are found to be lagging in this front. The absence of this fundamental prerequisite, known as the ‘digital divide’ limits the stakeholder’s ability to capitalise on many of the basic utilities of the geospatial industry. It is Big Data and the Cloud that are the two dominant technologies driving and accelerating the geospatial industry and capabilities. These are followed by AI and the IoT, but are heavily dependent on wireless and broadband internet applications as the backbone of the digital ecosystem. Its impact on empowering citizens in developing countries requires the necessary infrastructure to bridge the digital divide”* (Geospatial Media, 2018). These technologies and their evolution are presented in more detail in Chapter 3 of this dissertation.

5.4.1.3 Geospatial Policy Gap

Overcoming the many obstacles to close the gaps and bridge the geospatial digital divide requires considerable capacity and capability development, and knowledge transfer. But even more importantly, to be able to deliver and sustain an integrated and interoperable geospatial information environment in developing countries will require the appropriate tools – frameworks, standards, methods and guides – to be developed and institutionalised within countries through an enduring mechanism such as an overarching and strategic national framework. Strategic management and understanding is a key element to be considered. Strategic management as a process that consists of the analysis, decisions, and actions an organisation undertakes in order to create and sustain competitive advantage, and consists of four basic elements: environmental scanning, strategy formulation, strategy implementation and evaluation and control (Dess and Lumpkin, 2003; Wheelen and Hunger, 2006).

While the adoption of the 2030 Agenda provides the global policy mandate to exploit the contribution to be made by geospatial information to support the implementation of the SDGs, targets and indicators, does this provide enough for countries to implement the required change – and to bridge the geospatial digital divide? Therefore, and providing the means to ‘implement’ the bridging of both the digital divide and the geospatial digital divide, is the final and outer layer. The ‘Geospatial Policy Gap’ is where all of the elements are able to be brought together and consolidated within a National Strategic Geospatial Information Framework. This Framework is presented and described in Chapter 7 of this dissertation as a means to bridge the geospatial digital divide, and to provide a national basis and guide for countries to develop and strengthen arrangements in national geospatial information management as they attempt to measure and monitor progress towards the implementation of the SDGs.

5.5 Bridging the Geospatial Digital Divide

Whilst spoken of for several years in global conversations, the previous sections of this Chapter have, for the first time, introduced and described the ‘geospatial digital divide’. As illustrated eloquently

in Figure 5.7, bridging and overcoming the geospatial digital divide is both complex and multi-dimensional. With almost thirty individual elements that cover many socio-economic and technological realms, it is a lot for developing countries to comprehend and understand. That said, the highly visual and circular ‘donut’ view of the digital divide and geospatial digital divide has now been tested in several of the regional workshops and consultations (described in Chapter 4 and presented in Chapter 8), including four in Africa, since April 2018. It has been very well received as a methodology, but importantly, even more so as a means of communication for countries to explain to their decision-makers the many dimensions that are to be considered in bridging the geospatial digital divide. This has also greatly contributed to increased understanding of the integrated geospatial information systems framework (Chapter 6), and the design of the national strategic geospatial information framework (Chapter 7), of which ‘bridging the geospatial digital divide’ is a dedicated element in one of the nine strategic pathways.

Having now evaluated and described the existence of the geospatial digital divide in developing countries, what are its implications and how can it be remedied? In essence, many developing countries face the same digital divide and geospatial digital divide challenges, yet are addressing and prioritising them slightly differently, depending on context and local variations. There is no doubt that the combined momentum of the 2030 Agenda and digital transformation, including the Fourth Industrial Revolution, is having an impact, building digital capacities as an accelerator for SDG implementation. But there are still concerns that they are not yet inclusive enough and that (growing) disparities still exist (United Nations, 2019b). Unlocking the potential of digital technology offers opportunities to increase the effectiveness, efficiency and coverage of development, but national policy, laws and regulation should provide better direction and an enabling environment for technological progress.

Given the scale of the challenge, in the context of Africa, this needs to be considered not in a sequential way, but in an integrated way, and as a shared solution – African solutions for African problems (Sultan Mohammed Alya, personal communications, April 2019). Breaking Figure 5.7 down and treating the six layers like a donut, the following visual prompts can be observed. The inner most and outer most layers – the Digital Access Gap and the Geospatial Policy Gap – are displayed in the darker reddish ‘warning’ tones. This is because they are the most critical elements to bridging the geospatial digital divide. Like the inner and outer supporting skin/crust of a donut, if these two gaps are successfully addressed and are strong and stable, then the ingredients within will be able to be dealt with appropriately as resources, capabilities and capacities allow. The Data Ecosystem Gap is conversely represented by the ‘positive’ green tones, as this is actually where all of the other layers meet to deliver the required outcomes – integrated geospatial information and other location-based data. Bridging the Geospatial Technology Gap rests almost entirely with the innovations being developed by industry and the geospatial market. National governments will be observers to these rapid and agile developments and will mainly be challenged by how quickly they are able to ‘adopt and implement’. It

is worth noting that, in terms of just the geospatial digital divide, bridging the Digital Adoption and Digital Value Gaps will not be such an issue, as the opportunity, literacy and skills required to create content and use the available technology is expected to be at a much higher level than that of the general population – as they would typically be qualified geospatial practitioners.

In summary, breaking the six ‘gaps’ in Figure 5.7 down to the most basic levels, there are several fundamental impediments that are persistent and must be overcome to bridge the geospatial digital divide. These are:

1. **Digital Access:** Is core to bridging the digital divide and geospatial digital divide. Bringing people online in the first instance is both the greatest challenge and success. But Africa is in a special situation, with many nations being LDCs. Having access to reliable electricity and the Internet are the greatest impediments. Without these basic commodities, access to ICT, computers and technology becomes irrelevant.
2. **Digital Adoption:** While stemming from lack of skills, literacy and knowledge, it is lack of ‘opportunity’ to participate in the information society that is the greatest impediment. Bringing people online will increase skills and literacy at a rapid rate, particularly with the younger generations.
3. **Digital Value:** Inclusion (or exclusion), demographics (gender, race, ethnicity, age, education, social status) and geography (urban versus rural) are the main impediments, are almost entirely socio-economic in nature, and require medium to long-term strategies to be implemented by government to overcome them. The solutions to these problems reside outside of the realm of technology.
4. **Data Ecosystem:** The impediment – lack of data! More geospatial data, information and resources need to be accessible and online. Too much valuable ‘fundamental data’ is not open and sharable. The technology exists, but people do not want to share – even the most basic information. The value in making data openly available far exceeds the risks for doing so.
5. **Geospatial Technology:** The technology exists and digital transformation is growing every day, the impediment is access and literacy to use it. Harnessing and using technology, and with the appropriate skills and bandwidth (including high-end or low-end options), is the challenge. While technology opportunities remain unevenly distributed, they are solvable, and industry is leading in this area every day. Further, leapfrogging with technology is a very real opportunity.
6. **Geospatial Policy:** The lack of integrated and interoperable frameworks and guides has been the major impediment until now, but can be rectified through this research. The leadership and role of government and institutions as facilitators is critical to ensuring that no one is left behind, and should not be underestimated.

5.5.1 Geospatial Technology Leapfrogging

Given the context of this Chapter, it is appropriate to briefly discuss the ‘leapfrogging’ opportunities now being provided by the enabling technologies. Leapfrogging generally refers to the adoption of advanced or state-of-the-art technology in developing countries in an application area where immediate prior technology has not yet been adopted (Fong, 2009; Ranganathan, 2011). The leapfrogging is predicated on the theory that developing countries can be perceived to be at a relative advantage since they do not need to adopt the digital trajectory followed by the developed world. Instead, they can reap the benefits of years of research and development invested into by the developed countries to immediately adopt the cutting-edge technological offerings, thereby bypassing the entrenched intermediary technology that are used widely in developed countries (Ranganathan, 2011).

For example, millions of people in developing countries leapfrogged to mobile phones without having ever owned or used landline telephones. Similarly, populations in many developing countries, with no electricity until now, are adopting solar electricity, bypassing fossil fuels and leaping directly to the stage of renewables. In fact, many developing countries now derive higher shares of their electricity from renewables compared with many developed countries (United Nations, 2018c). It is possible, with appropriate policy measures and strategies, to encourage these developments and accelerate the general process of technological catch-up for many developing countries (United Nations, 2018c). Similarly, while lack of reliable electrical power and internet in some parts of Africa still pose challenges to new technology, there are adaptations in which data is collected offline on mobile devices and then transmitted to servers when an internet connection is available (GSDR, 2015).

New and advanced technology provides developing countries with the opportunity to accelerate economic development (OECD, 2018b). However, technology leapfrogging may pose high risks if immature or unproven technologies are involved. Despite this, and given that there may be no other satisfactory alternatives, the risks can be managed and minimised by careful planning and evaluation. In a geospatial context, this often means choosing between bypassing the heavy legacy geospatial technology, infrastructure and practices adopted in past years by developed countries, and leaping with technology to more agile and flexible geospatial solutions that leverage technology, Cloud services, the semantic web, and analytics – but which in themselves have a fundamental reliance on Internet access and bandwidth. Notwithstanding these potentials, for many developing countries, particularly countries in special situations, formidable barriers to leapfrogging to new technologies still exist, not the least being broadband Internet connection.

The 2030 Agenda for Sustainable Development makes a commitment to leave no one behind. This means that no country or country group should be left behind, as technological advances create new opportunities for economic growth and prosperity (United Nations, 2018c). Technologies, both existing and emerging, present the best hope for bridging the geospatial digital divide and achieving broad-based sustainable development outcomes in developing countries. To meet this potential,

countries will need to develop, strengthen and modernise their approaches to geospatial information management, including aspects relating to geospatial information policies, governance, data integration and infrastructure, enabling technologies, education, innovation, use and collaboration. Considerable policy intervention will be needed at national, regional and global levels to make sure that the new technologies do not widen the technological divide and leave many developing countries further behind (United Nations, 2018c).

5.6 Chapter Summary

Framed by the requirements of the SDGs, and with a focus on Africa, the concepts and expectations of rapidly growing global interconnectivity, and knowledge and information societies, this Chapter investigated and evaluated the existence and implications of the digital divide that continues to exist today for developing countries, particularly as it pertains to sustainable development. It then introduced and discussed the concepts of the geospatial digital divide and the complex challenges that continue to exacerbate the ability for developing countries to bridge this divide and accelerate human progress. The Chapter then discussed options for countries to close the gap in the geospatial digital divide, including to develop, strengthen and modernise their approaches to national mapping and geospatial information management. These gaps include: digital access; digital adoption; digital value; the data ecosystem; geospatial technology; and geospatial policy. Understanding and articulating these gaps provides both uniform structure and language for developing countries to use to communicate their needs to policy and decision makers.

The next Chapter designs and describes a general integrated geospatial information systems framework, an integrative sustainable development 'data flow' framework to provide the building blocks and processes for countries to measure and monitor the SDGs.

Chapter 6 – Integrated Geospatial Information Systems Framework

6.1 Introduction

As mentioned briefly in Chapter 1 and described in more detail in Chapter 5, the development, and then implementation, of a national strategic geospatial framework could not be achieved without considering and addressing the significant dependencies on geospatial data and enabling technologies, bridging the geospatial digital divide, and an integrated geospatial information systems framework (Figure 1.2). Chapter 5 detailed the geospatial digital divide with reference to major gaps for developing countries in the data ecosystem, technology and policy. It particularly referenced the ‘Data Ecosystem Gap’ as the fourth layer relating to the lack of access to, and exploitation of, data itself – the vast amounts of geospatial data, Earth observations, statistics (population, socio-economic and environmental), Big Data and the many new and emerging data sources. This included the ability to access online data, information and resources, as well as the ability to share and disseminate digital data and information, provides countries with the much needed global interconnectedness in order to communicate with and transition to knowledge and information societies.

Building upon these significant data gaps, this Chapter designs and describes a conceptual integrated geospatial information systems framework as an integrative sustainable development ‘data flow’ that is anchored by the NSDI, providing the underpinning building blocks and processes for countries to measure and monitor the SDGs. The framework is able to integrate national information systems, particularly statistical and geospatial data, for reporting on the global indicator framework, from local real-world conditions to global harmonised reporting through robust and reliable data inputs. This Chapter addresses the ‘Integrated Geospatial Information Systems Framework’ component of the dissertation as illustrated by Figure 1.2 in Chapter 1.

6.2 Integrating Geospatial Information, Statistics and Earth Observations

As described in detail in Chapter 2, the 2030 Agenda captures the specific need for *“high quality, timely, and reliable data, including Earth observations and geospatial information, that is disaggregated by income, gender, age, race, ethnicity, migratory status, disability, geographic location and other characteristics relevant in national contexts”* (United Nations, 2015a, p. 27). With global policy and intergovernmental mechanisms now recognising and calling for the need to integrate geospatial information into sustainable development processes, the challenge for national geospatial information (and other related data) agencies in many countries is what tangible action can be taken. Firstly, one must consider how the SDGs will be measured and monitored, and how progress is made within and across countries. Then, where is the data and evidence coming from? What are the signals or indicators of progress being made and what is the framework and context?

In early 2018, the co-Chairs of UN-GGIM noted that *“the integration of statistics, geospatial information, Earth observations, and other sources of Big Data, combined with new emerging technologies, analytics and processes, are becoming a fundamental requirement for countries to*

measure and monitor local to global sustainable development policies and programs. Today a large proportion of the global community have an entirely different set of Earth observations and geospatial information uses, needs and expectations than they did 10 years ago. But more is needed” (CEOS, 2018, p. iv). The need to understand the interrelationships across the three pillars of sustainable development – economic, social and environmental – and the impact of the environment on socio-economic activities, and vice versa, will be critical.

6.2.1 Global Statistical Geospatial Framework

Within many national governments, there has been for some time a clear recognition of the need to link statistical information (primarily socio-economic information) and geospatial information (primarily environmental information) to improve sub-national data, its disaggregation, and the relevance of the evidence on which decisions are made. Geographic location is increasingly recognised as key to virtually all national statistics, providing a structure for collecting, processing, storing, aggregating and disseminating data. Put simply, linking people, business and the economy to a particular place or geographic location can result in a fuller understanding of social and economic issues than is possible through a socio-economic information lens on its own (United Nations, 2015h).

This was recognised by the United Nations Secretary-General in his report to the United Nations Statistical Commission (Statistical Commission) in 2012 on global geospatial information management, in which he noted that one of the key challenges was a better integration of geospatial and statistical information as a basis for sound and evidence-based decision-making (United Nations, 2012c). The geographic dimension is increasingly considered as key to virtually all national statistics, as it provides the spatial framework and structure for collecting, processing, storing and aggregating the data. Furthermore, it is generally recognised that ‘adding location information increases the value of statistics’ (United Nations, 2013d).

In order to best exploit the synergies of both professional domains and information systems, in 2013 the Statistical Commission and UN-GGIM established the United Nations Expert Group on the Integration of Statistical and Geospatial Information to pursue the implementation of a global statistical-geospatial framework in the 2020 Round of Censuses, with the understanding it would apply to other initiatives including other censuses, such as agriculture censuses, economic censuses, etc., and global initiatives such as the development agenda (United Nations, 2013b).

Following five years of development, the Global Statistical Geospatial Framework (GSGF) is now complete (UN-GGIM, 2019b), and was adopted by UN-GGIM at its ninth session in August 2019. The GSGF is recognised as an important bridge that enables a range of data to be integrated from both the geospatial and statistical communities and that permits the production of harmonised, standardised and integrated, geospatially enabled statistical data to facilitate data-driven decision-making (United Nations, 2019c). Figure 6.1 provides an overview of the GSGF, which features a series of data Inputs,

required Principles, applied Key Elements and subsequent integrated information Outputs. At the core of the GSGF's integration characteristics are its five Principles. These outline the broad processes by which a range of geospatial and statistical data infrastructures and processes are applied to input data to enable integration. Firstly, the statistical data are geospatially-enabled to the finest level possible, typically at the unit, parcel or address level. Then, geospatial tools and methods, such as common geographies and common standards of good practice, are used to ensure the data are interoperable, accessible, and usable (UN-GGIM, 2019b).

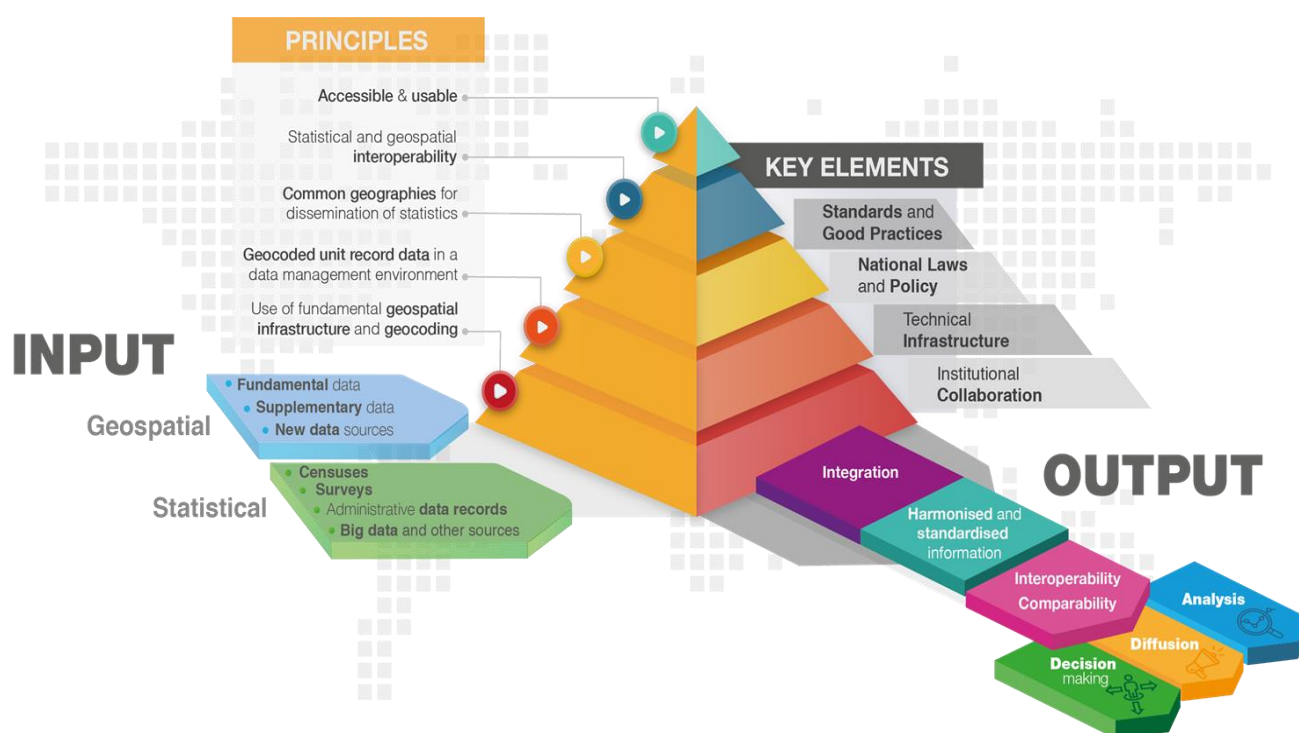


Figure 6.1: The main components of the Global Statistical Geospatial Framework (UN-GGIM, 2019b).

A strength of the GSGF is that it is only intended for, and limited to, statistical and geospatial data integration, not for integration of other data sources, types or information systems, including for example Earth observations and environmental data. A weakness is the present articulation of the 'Key Elements' of the GSGF (standards, good practices, national laws and policy, technical infrastructure, and institutional collaboration) (Figure 6.1). While they are identified as *"playing a critical enabling role that allow data to be obtained from the various sources and the GSGF Principles to be applied"* (UN-GGIM, 2019b, p.7), the Key Elements are 'assumed' as being institutionally in place, available, and in practice. For many developing countries this is not the case; hence the need for an overarching national strategic framework that captures these important elements.

6.2.2 Measuring and monitoring through the global indicator framework

Chapter 2 (Section 2.3.2) described some of the key learnings from the first four years of implementation of the 2030 Agenda; a common thread being the lack of important baseline data and

enabling technologies to measure and monitor progress. As referenced earlier in this Chapter, more is needed. The 2019 Sustainable Development Goals Report (United Nations, 2019a) highlights that a much deeper, faster and more ambitious response is needed to unleash the social and economic transformation needed to achieve the SDGs, that *“quality data are vital for governments, development partners, international organisations, civil society, the private sector and the general public to make informed decisions and to ensure an accurate review of the implementation of the 2030 Agenda”*. The Report reiterates that *“new data sources and technologies for data collection and for the integration of various data sources will need to be explored, including through partnerships with civil society, the private sector and academia. The integration of geospatial information and statistical data will be particularly important for the production of several indicators”* (United Nations, 2019a, p.58).

It is acknowledged that the constraints faced by many developing countries in producing the data necessary to address the indicator requirements will remain an ongoing capacity issue for some time, if not indefinitely. Due to their multi-dimensional nature, complexity and breadth, monitoring of and reporting progress on the SDGs requires significant improvements in supporting the national system of statistical information within countries. Existing national data inputs and coordination mechanisms, previously established for monitoring and reporting on the MDGs, should be augmented so as to broaden the scope of the socio-economic dimensions to include the environmental and location dimensions. Thus, as an absolute minimum, integrating statistics, geospatial information and Earth observations, as the core information system inputs into the global indicator framework, will be a fundamental requirement to ensure sustainable data for sustainable development (Figure 6.2). These inputs will need to be informed by good science, robust methodological approaches, enabling technologies, and sound policy.

As noted in Chapter 2 (Section 2.3.2), the Statistical Commission established the IAEG-SDGs at its forty-sixth session in March 2015, prior to the adoption of the 2030 Agenda, to develop the global indicator framework as the quantitative means by which countries can consistently measure and monitor achievement on, and report progress towards, each of the anticipated 169 targets of the SDGs (United Nations, 2015h). Following a rigorous process of development and debate within the IAEG-SDGs, including reporting through the Statistical Commission and ECOSOC, the global indicator framework, as a voluntary and country-led instrument that consists of an initial 232 indicators, was adopted by the General Assembly in July 2017 (United Nations, 2017c) – more than two years after the work began in March 2015. In their adoption, it was recognised that many of the indicators still had no supporting data for countries to measure and monitor their development progress.

Therefore, to facilitate the implementation of the global indicator framework, the IAEG-SDGs took the step of classifying all indicators into three tiers based on their level of methodological development and the availability of data at the global level, as follows:

Tier I: Indicator is conceptually clear, has an internationally established methodology and standards are available, and data are regularly produced by countries for at least 50% of countries and of the population in every region where the indicator is relevant;

Tier II: Indicator is conceptually clear, has an internationally established methodology and standards are available, but data are not regularly produced by countries; and

Tier III: No internationally established methodology or standards are yet available for the indicator, but methodology/standards are being (or will be) developed or tested (United Nations, 2017e).

The intent is that all indicators will be eventually elevated to Tier I. However, as of December 2019, there are 116 Tier I indicators, 92 Tier II indicators and 20 Tier III indicators. In addition to these, there are 4 indicators that have multiple tiers (different components of the indicator are classified into different Tiers) (IAEG-SDGs, 2019). To summarise, after four years of implementation of the SDGs, there remain more than 112 indicators, almost half of the 232 global indicators, in which data are not regularly produced by, or even available for, countries. This one statistic alone validates the justification for this dissertation.

It is intended that the indicators be refined annually and reviewed comprehensively by the Statistical Commission in 2020 and 2025, and will be complemented by indicators at the regional and national levels, which will be developed by countries. The United Nations (2017b) contains the official list of 232 global indicators and their metadata as an annex. These are replicated in Appendix 1.

The global indicator framework, which is highly dependent on diverse and reliable data to provide the evidence base for decision-making and reporting, provides the quantitative means by which countries can consistently measure and monitor achievement on, and report progress towards, each of the 17 SDGs and 169 targets. It represents the first truly data-driven framework in which countries can engage with the aim of evidence-based decision-making and development policies (CEOS, 2018). Figure 2.5 (Chapter 2, Section 2.3.2) demonstrates that the real data inputs and subsequent outputs, and hence accountability for results, will be through the global set of indicators which rely entirely on real-world data – statistics, geospatial, Earth observations, and other Big Data – on a range of social, economic and environmental metrics (see also Figure 6.2).

The initial development of the global indicator framework was almost entirely a statistical data approach by the IAEG-SDGs, based on the similar history of the MDGs. But the need for ‘geographic location’ in a new era of data needs has now been recognised. Noting that there are considerably more indicators than targets, the process of developing the indicator framework by the IAEG-SDGs highlighted several key issues regarding the production of indicators with non-statistical data, including being able to address the issues of alternative and new data sources and methodologies – and particularly using geospatial information and Earth observations data.

Therefore, UN-GGIM and the Group on Earth Observations (GEO) worked closely with the statistical community, at a national and global level, to provide inputs into the processes to develop the global indicator framework with the IAEG-SDGs (Anderson et al., 2017; CEOS, 2018; Kavvada and Held, 2018). Through this process, the statistical community now understands that geospatial information and Earth observations are able to provide new and consistent data sources and methodologies to integrate multiple ‘location-based’ variables to support and inform official statistics and the indicators for the SDGs. These methods are able to fill data gaps and/or improve the temporal and spatial resolutions of data, by bringing together information from various sources, particularly those related to the environment.

However, determining the global indicators was just the first step, as they needed to then be appropriately interpreted and implemented, guided by robust data and metadata. Further, the compilation and dissemination of appropriate metadata on the indicators will be critical in order to ensure their consistent implementation at sub-national, national, regional and global levels. Such metadata will need to encompass a full description of the indicator definitions, underlying concepts and methods of data collection, data sources and other relevant information that would facilitate the use and interpretation of the indicators (United Nations, 2016d).

As a means to address these issues and specific areas relevant to SDG indicator implementation, the IAEG-SDGs established a Working Group on Geospatial Information at its third meeting in April 2016. The Working Group provides expertise and advice to the IAEG-SDGs and the larger statistical community as to how geospatial information, Earth observations and other new data sources can reliably and consistently contribute to the global indicators. Its initial work was to review the agreed 232 indicators and metadata through a ‘geographic location’ lens and identify existing geospatial data gaps, methodological and measurements issues (UN-GGIM, 2016).

Building on these SDG implementation requirements and Figure 2.5, Figure 6.2 provides a conceptual overview of the ‘sustainable data for sustainable development’ requirements for the SDGs. Anchored by statistics, geospatial information and Earth observations as the key integrative data sources, this includes a series of data ‘needs’ that have emerged over the first four years of reporting progress on the measuring and implementation of the SDGs. These include:

1. The need for high quality, accessible, timely and reliable data that is disaggregated by a number of metrics (income, gender, age, race, ethnicity, migratory status, disability, geographic location and other characteristics relevant in national contexts) as described in the 2030 Agenda (United Nations, 2015a, p. 27).
2. The need to include all parts of the data ecosystem, including new and emerging data sources.
3. The need to include data on a wide range of topics as defined by the SDGs; requiring an unprecedented amount of data.

4. To achieve these data needs, interoperability and integration of systems is crucial to harnessing the potential of all types of data.

This is predicated by the 2030 Agenda requiring new data acquisition and integration approaches to improve the availability, quality, timeliness and disaggregation of data to support implementation at all levels. Data disaggregated by income, gender, age, race, ethnicity, migratory status, and disability are ‘people’ centric; while geographic location refers to ‘place’. Therefore, the new data needs are for determining and measuring the relationship between ‘people and place’ in the disaggregation process.

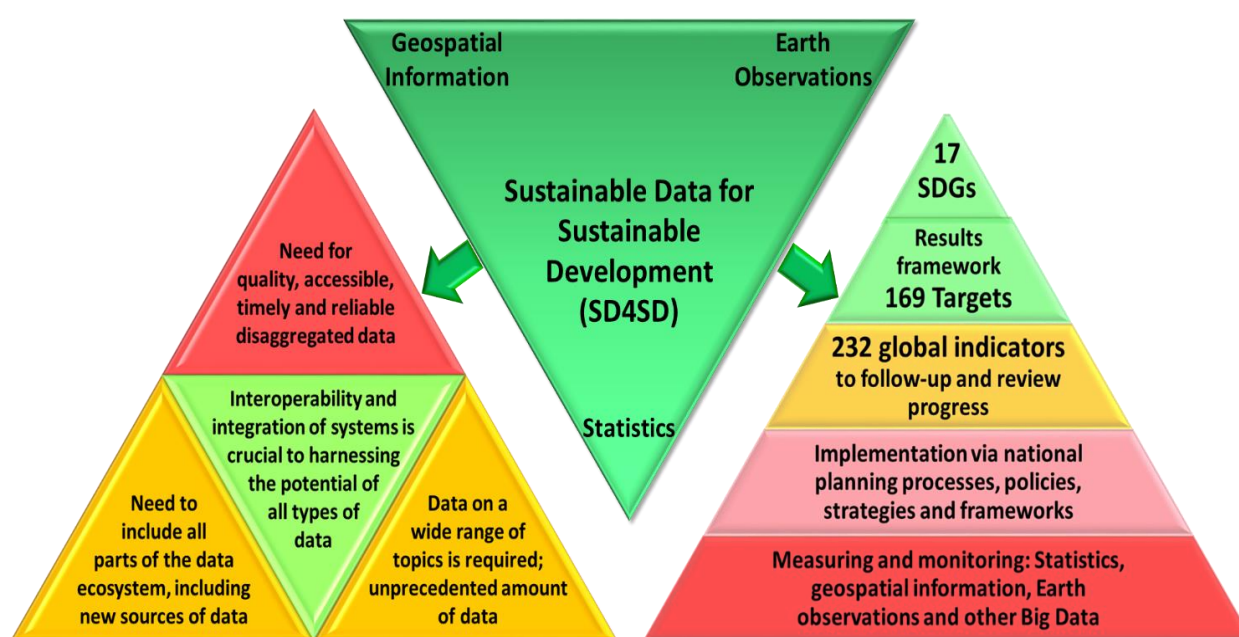


Figure 6.2: Global outputs and reporting progress through the indicators, targets and goals; key areas of national data inputs towards the production of the global indicators; and a series of data ‘needs’ which have emerged over the first four years of reporting progress on the SDGs.

6.3 Integrated Geospatial Information Systems Framework

The data needs to measure progress have been identified since the adoption of the 2030 Agenda, but what and where is that data, and what are the policy and data frameworks and methods to enable its realisation? In combination with the traditional statistical, socio-economic data used by countries, geospatial information and Earth observations, with modern data processing and Big Data analytics, offer unprecedented opportunities to make a quantum leap in the capacities of countries to efficiently track all facets of sustainable development and to make viable the prospect of a global indicator framework for the SDGs. Implementation of the geospatial information systems framework requires consistent and persistent data – the national agency data, information systems and their related cross-government coordination, collaboration, data integration and interoperability. These national information systems, combined with other sources of new data, need to contribute to the fundamental

baseline data inputs, as well as any new required data collections, all parts of the data ecosystem, so that countries will be better able to measure and monitor progress and transformative change within their individual national circumstances.

The goals, targets and indicators of the SDGs will need to be consistently tracked over long periods of time at varying scales, and so that comparability across nations can be achieved, including through to globally harmonizing national data. The location element of data, including statistical data, will be a critical consideration. Figure 6.3 provides a general integrative sustainable development ‘data flow’ framework, as an enabling environment where organisations can cooperate and improve on the management and exchange of data within these national information systems, is able to provide the mix of national data, building blocks and processes for countries to measure and monitor the SDGs from local real-world conditions to global harmonised reporting through robust and reliable data inputs. In order to be effective and avoid duplication of technology and resources, the data flows need to be cross-cutting across multiple government agencies, and need to leverage existing NSDI capabilities and methodologies; while also being able to gather and deliver new data not previously considered. These interoperable systems and data flow capabilities are able to integrate, analyse, model, manage, measure, monitor and disseminate all types of data to support national development.

With reference to Figure 6.2, there are distinct elements of the ‘data-information-knowledge’ concepts that can be applied as a fundamental component of an integrated systems framework (Aamodt and Nygard, 1995). A further adaptation for systems engineering and information science is the Data-Information-Knowledge-Wisdom (DIKW) pyramid, or the knowledge pyramid (Ackoff, 1989; Frické, 2018). Data is the foundation of the pyramid, information is the next layer, then knowledge, and finally, wisdom is the apex. This hierarchy is often quoted, or used implicitly, in definitions of data, information and knowledge in the information management, information systems and knowledge management literatures (Frické, 2018).

Ackoff (1989) concludes that information systems generate, store, retrieve, and process data, and that in many cases their processing is statistical or arithmetical. In either case, information is inferred from data. Knowledge is then know-how, how a system works and what makes possible the transformation of information into instructions, which in turn control and make a system work more efficiently. Wisdom adds value to data, information and know-how, requiring the mental functions of judgement and insights, and is a prerequisite for decision-making (Ackoff, 1989). While not perfect, an expanded adaptation of the DIKW pyramid principles have been applied to provide context and structure for an integrated geospatial information systems framework. Working from the base of Figure 6.3, the building blocks and data flow of the framework are as follows:

(1) Problem: The local to national real-world development reality, the social, economic and environmental sustainable development challenges, conditions and circumstances that exist for

countries, and that need to be measured and monitored in order to make progress. For the least-developed countries and SIDS, limited capabilities and resources, including the means to even understand these conditions and their implications, will initially remain a significant capacity challenge. As described in Chapter 5, the ambitions to bridge the digital divide are intrinsically embedded into this development reality. In summary, understanding the breadth and depth of the development problems and realities that both exist and are emerging, including their interdependencies, is a challenge for all countries – developed or developing;

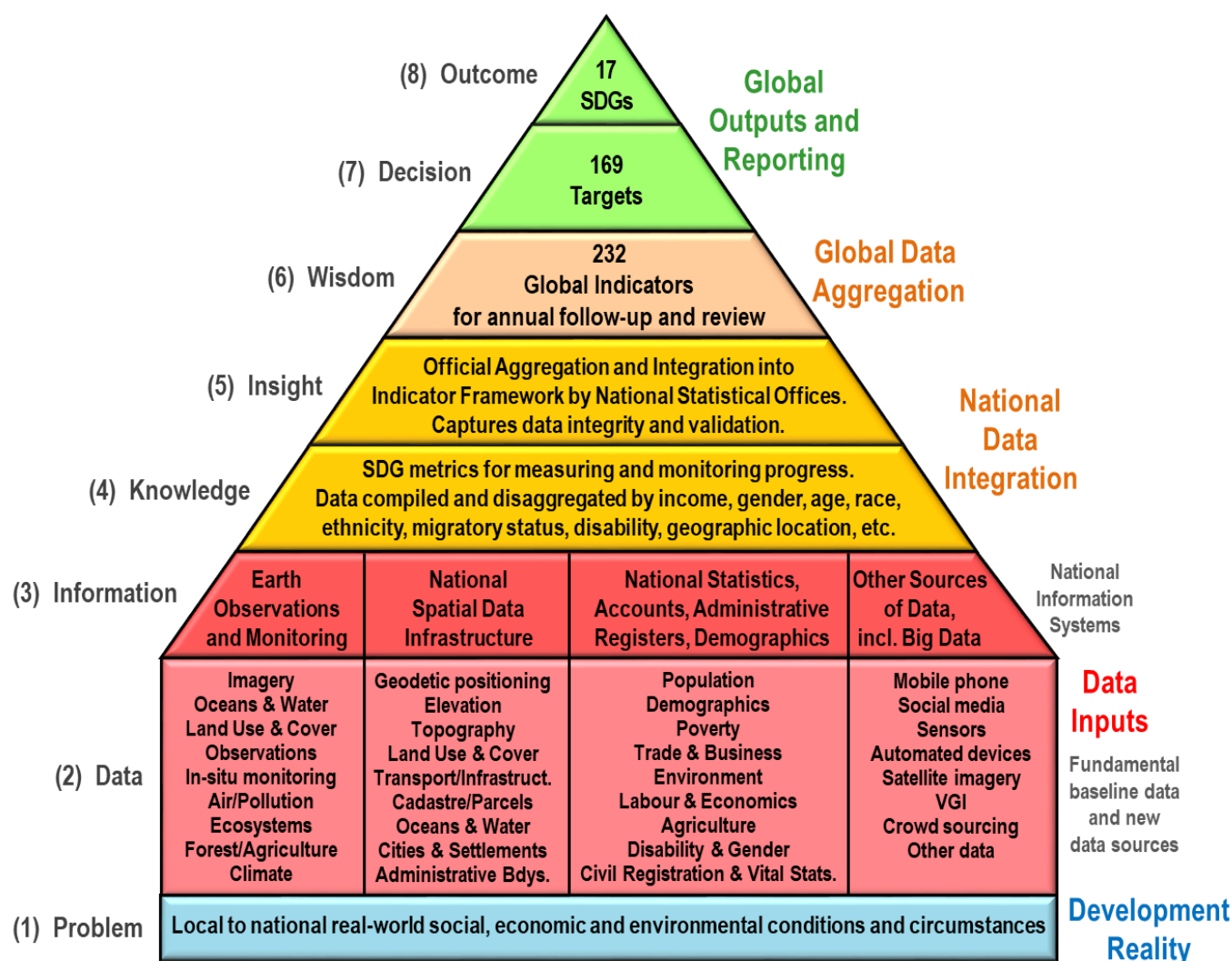


Figure 6.3: A general national information systems sustainable development ‘data flow’ framework that provides the building blocks and processes for any given country to measure and monitor the SDGs from local real-world conditions through to global harmonised reporting.

(2) Data: Comprises the many and varied mix of fundamental baseline data resources and inputs, including new data collections, which will be required. Recognises the need for quality, accessible, timely and reliable data on a wide range of topics, and to include all parts of the data ecosystem, including new sources of data (Figure 6.2). The four sets of data classifications listed are derived from

the four national information system classes and capture the main fundamental and baseline data that are created and provided by the Earth observations, geospatial, statistical, and statistical Big Data communities. Many of these data may need to be ‘repurposed’ or significantly improved in order to adequately measure and contribute to the determined national indicators. In many countries, there is a steady increase in the number of government agencies, businesses and related organisations that collect and curate geospatial and non-geospatial data, as well as end users that are continually adding value to data and redistributing it as new products. However, the data is often not well shared or integrated across the broader government sector, nor in a format that can be easily used and consumed for analysis. This limits the full use and realisation of these large authoritative data repositories – which are often kept and managed in closed systems and isolated siloes, making data integration and exchange problematic;

(3) Information: The exploitation of the national ‘information systems’, analytics and associated enabling tools and technologies, many of which are becoming more web-dependent, will be needed to support the implementation of the SDGs. Recognises that the interoperability and integration of systems is crucial to harnessing the potential of all types of data (Figure 6.2). The four national information systems classes – Earth observations, the NSDI, Statistics, and Other sources – represent the primary groups of information and systems that could be readily adapted and used to support the data compilation and disaggregation by the various metrics determined by the 2030 Agenda. Countries will be required to provide the means to ensure access to high quality, timely and reliable data that are structured, organised and managed, ideally in an interoperable and standards-based manner, so that it can be easily incorporated, discovered and used/reused for decision-making. Well established geospatial information system technologies, such as the NSDI, are able to readily provide the integrative platform ‘data flows’ and ‘glue’ for all digital data that has, or can have, a location dimension to it. Geospatial information provides the digital connection between a place, its people and their activities, and is used to illustrate what is happening – where, how and why. For this reason, geospatial information needs to be integrated across government processes and services, and managed according to guidelines within the broader data, governance and technology frameworks of government. Once integrated, geospatial information becomes a powerful tool for determining appropriate national policy interventions and decisions for a wide variety of SDG needs;

(4) Knowledge: This is the intersection or integration point between fundamental baseline data and national information systems, with the specific needs and metrics for measuring and monitoring SDG progress; to translate information into knowledge and understanding. The appropriate integrated data that are provided through the national information systems are specifically purposed, compiled and disaggregated by a number of SDG metrics; specifically, by income, gender, age, race, ethnicity, migratory status, disability, geographic location and other characteristics relevant in national contexts. The data flows and steps from information to knowledge (and understanding) are often the most difficult. However, the benefits are considerable as, through understanding, insights can be gained. For

example, the disaggregation of statistical data by geographic location and the aggregation of geocoded unit-level data, enables location-based disaggregation by metrics that can readily include: rural, urban, cities, villages, informal settlements, built-up areas, open spaces, etc. along with their relationships with the requirements of the indicator framework, and over time;

(5) Insight: This is where the data flows through the National Statistical Offices, as the coordinator of the national statistical system, whom will then undertake and finalise the official aggregation and integration into national country indicators, ensuring data integrity and validation. Insight is the deepest level of knowledge, and represents an additional layer in the pyramid, as the knowledge in the previous step is then deepened as it is applied to individual indicators. Through insight and judgement, the focus should be placed on enhancing a consistent and coordinated approach for processing data and metadata, particularly with regards to data validation and the communication of estimates and adjustments undertaken by national and international statistical systems to produce internationally comparable data for the indicators;

(6) Wisdom: The National Statistical Offices, and in collaboration with specialised United Nations agencies where appropriate, then provide the final national indicators to the United Nations Statistics Division to be compiled into the global reporting on SDG indicators with other countries around the world so that the global outputs can be reported. As decided by the Statistical Commission, estimates used for the compilation of global indicators are to be produced in full consultation with National Statistical Offices;

(7) Decision: Aggregated initially as the 169 aspirational global targets; and

(8) Outcome: Finally, as the 17 universal SDGs. These processes occur on an annual basis and are formally reported through the annual Sustainable Development Goals Report.

With further reference to Figure 6.3, at the global level the 17 SDGs, and 169 targets, as ‘Global Outputs and Reporting’, were determined by the political process in the adoption of the 2030 Agenda by all countries, and are now being implemented as policy by governments (and therefore coloured green). The 232 global indicators, as the ‘Global Data Aggregation’ for annual follow-up and review, were determined by the Statistical Commission. The associated methodologies and data requirements within countries and international agencies are still variable and captured on a best-effort, as-available and comparable basis (and therefore coloured brown). The ‘National Data Integration’ is where the inputs from the National Information Systems are integrated, aggregated and disaggregated against the required SDG metrics. While the policy process, through National Statistical Offices, has been determined, the means to compile and disaggregate the data have not yet been well articulated. National statistical and geospatial experts are presently considering these data processes under the guidance of the IAEG-SDGs and its Working Group on Geospatial Information, so they are still work in progress (and therefore coloured orange) (UN-GGIM, 2019a).

The local to national ‘Data Inputs’ comprise two critical parts; the first being where the fundamental baseline data and other sources of new data will come from. The data flow framework recognises that this is presently a melting pot of potentially rich data within and across many government and research agencies in countries, but not yet specifically aligned or re-purposed to the needs of the SDG metrics, as shown in Figure 6.3 for the case of the NSDI data themes (and therefore coloured pink). The second part of the Data Inputs, and the most critical to the success of the national strategic geospatial information framework, are the ‘National Information Systems’ and their related cross-government coordination, collaboration and data integration. This is where the future directions of the framework need to be investigated and targeted so that there is an enabling environment where organisations can cooperate and improve on the management and exchange of data within these national information systems.

The area of greatest potential influence (and therefore coloured red) are the National Information Systems, as the means to provide the integrative data information systems for government and sustainable development outcomes; with reliable, authoritative, repeatable, the best available and fit-for-purpose data. Should this legal, organisational, semantic and technical interoperability be achievable, then how data is acquired, connected, integrated and disseminated, and by what levels of geographic coverage and disaggregation, or even aggregation, is then dependent on the user needs and specific problems being addressed (European Union, 2017). Through the United Nations intergovernmental processes there is now a very strong linkage between the statistical, geospatial and Earth observation communities, but much more needs to be achieved in order to realise greater national ‘institutional interoperability’.

Finally, the framework cannot overlook the real-world ‘Development Reality’ problem, the development challenges and circumstances within individual countries (coloured in blue) which is where the real measures of progress and success need to be ultimately determined. The biggest task here is determining a comparative process whereby measuring progress of the SDGs at the global level corresponds with the progress and realities at the national and local level.

6.3.1 National Information Systems

Chapter 3 (Section 3.7) discussed NSDI (and SDI) concepts as enabling national to regional information architectures, but did not elaborate on their role in the data ecosystem of the future. Such NSDI concepts, while reflecting the primary focus on geospatial data and its use, validated the essential role geospatial information would play in modern society and still apply today. The aim being to deliver as much publicly collected geospatial information as possible and make it widely accessible and available in a timely manner and at minimum cost. The long-standing virtues of NSDIs have been their ability to promote and provide geospatial data sharing throughout all levels of government and society, enabling effective use of geospatial data for sustainable national development and other every day requirements. But this is changing quickly – at least for the developed countries. With exposure to more

and more location-based geospatial information, combined with technologies that have democratised the user experience, particularly through smart phones and related location-enabled devices, the needs, demands, and expectations are changing the role of NSDIs. Standard data products and ‘push-pull’ data services are insufficient in responding to the emerging user-centric needs, demands, and expectations.

As has been described in Chapters 3 and 5, the digital transformation potential and technology innovations in the geospatial information sector are becoming major industry disruptors, particularly in the developed world. Geospatial information has emerged as a major contributor to economic transformation in many countries and is a critical component of a national infrastructure and knowledge economy. Additionally, national circumstances are a primary force guiding the need for, and management of, geospatial information capabilities. Through NSDIs, geospatial information can provide the means to integrate a wide variety of government services that contribute to economic growth, national security, sustainable social development, environmental sustainability and national prosperity. However, as has been detailed in considering the geospatial digital divide, developing countries have yet to have the opportunity to leverage this digital transformation potential and the emerging capabilities of NSDIs. In fact, the fear is that as technology advances, the gap between the developed and developing countries is widening.

Figure 6.3 identifies the NSDI as the national geospatial information system of the sustainable development data flow framework. For many developed countries it is the NSDI, and the provision of reliable fundamental geospatial data, that has the ability to provide both the enabling platform and connection point to other national information systems and to the SDGs. Given this history, the NSDI – or subsequent evolutions thereof – has the very real potential to be more important than ever as an integrative framework, but it must now be viewed and leveraged in a more strategic and integrated manner to do so. This means change in the form of a strategic framework as described in Chapter 7. What is needed to establish or maintain an integrated national geospatial information system is not sufficiently addressed by the NSDI in its current incarnation. There are arguably three key factors that now challenge the limitations and legacy of first and second generation NSDI approaches (and detailed more in Chapter 8 in Section 8.3.5.4).

The first is that historically, efforts at simply achieving an NSDI have focused on creating an NSDI rather than developing national geospatial capacity to address priority societal, economic and environmental decisions. The second is the recent and growing availability of more diverse data and more data types and needs that are now more relevant and dependent on geospatial data than were originally considered. The third limitation is the need for data integration and analysis. First and second generation NSDIs are very structured (stovepipes) repositories of valuable geospatial information, with defined and managed (separate) data sets and themes. Today, there is a shift to a more user-centric and user-driven perspective. Commensurately, these data assets must meet more diverse and specific local and national requirements and need to be ‘integrated’ with other data and sectors.

By way of a very simple example, why is it that interpolated contours are still being provided as part of many national topographic databases when high resolution digital elevation models and LiDAR (Light Detection and Ranging) point clouds are both available, are of a much higher accuracy, and have the ability to be used for many more functions and purposes? The modern and agile policy-oriented NSDI, like the considerable and rich data it provides, should no longer be seen as a special black-box solution as a means for thematic mapping and data delivery. It now has the opportunity to become a mainstream information system.

Additionally, the NSDI should no longer operate in isolation to other national information systems. Instead, it needs to be a system of interoperable systems (European Union, 2007, 2011a, 2011b), used for data integration, analysis, modelling, aggregation, fusion, and communication, and for its true capabilities; for organising, integrating and delivering data across disciplines and a wide variety of government services. There will need to be more integration across the various national information systems and platforms in order to leverage the best and most efficient data and analysis for policy and evidence-based decision making. The NSDI of the future, fuelled by high quality, timely and reliable fundamental geospatial data, could provide the means to organise and deliver core geographies for many national outcomes – including contributing to economic growth, national security, sustainable social development, environmental sustainability and national prosperity. In this regard, Chapter 7 develops a new national strategic geospatial information framework as a solution to these problems.

6.3.2 Fundamental Baseline Data

The lessons from 15 years of measuring and monitoring the MDGs, with only 8 goals, taught the world that data are an indispensable element of development; that *“strengthening data production and the use of better data in policymaking and monitoring are becoming increasingly recognised as fundamental means for development”* (United Nations, 2015c). The importance of fundamental baseline data should not be underestimated in national to global development, including the 2030 Agenda. Without data, measuring, monitoring, comparing and implementing development priorities is not possible, such is its importance. With reference to Figure 6.3 and the previous Section, the NSDI of the future is able to provide the integrative platform ‘data flows’ and ‘glue’ for all digital data that has, or can have, a location dimension to it. Within the environment of the NSDI, integrating new data sources and collections, and re-purposing fundamental or baseline data into specific thematic topics for addressing the needs of the indicator framework is not technically difficult and has multiple benefits in many areas – assuming that the data already exists in some way, is standards-based, interoperable, and is available.

Such data concepts were first considered by UN-GGIM at its fourth session in August 2014. At that time, and contextualised by an ‘inventory of issues’ gathered by countries that should be addressed in coming years (UN-GGIM, 2012c), UN-GGIM considered *“that a continuing gap in the successful unification of a national, regional and global geospatial information management capability is the lack*

of an agreed set of readily available and authoritative global reference datasets by specific themes. The importance and value of ` geospatial information, and the core fundamental reference geographies upon which all other information is based, is recognised by all Member States” (UN-GGIM, 2014c). Further, UN-GGIM recognised that within the global geospatial community, multiple terminologies were being used interchangeably and synonymously. These included ‘fundamental data’, ‘core data’ and ‘framework data’. UN-GGIM agreed that ‘fundamental’ would be used to emphasise the concept of geospatial data being fundamental baseline data and information to contribute to the overarching vision of the Committee to contribute to the 2030 Agenda and sustainable development (UN-GGIM, 2014c).

Notably, the original genesis and motivation for the need to determine a set of fundamental geospatial data themes came from Africa. When committing to developing initiatives to collect geospatial information within the context of the MDGs, Africa noted that there was a plethora of options for countries to explore; but what were the fundamental data needs that offer the best opportunity for a country to thrive? UNECA, was the first to recognise this challenge and took the lead in developing fundamental geospatial data with their 2007 report ‘Determination of Fundamental Datasets for Africa: Geoinformation in Socio-Economic Development’ (UNECA, 2007). Using inputs from the various collaborators from the many international and African institutions and the literature reviewed, the report determined that *“fundamental data sets are the minimum primary sets of data that cannot be derived from other data sets, and that are required to spatially represent phenomena, objects, or themes important for the realisation of economic, social, and environmental benefits consistently across Africa at the local, national, sub-regional and regional levels”* (UNECA, 2007).

UN-GGIM considered the determination of global fundamental geospatial data themes and agreed that such data themes needed to be integrated and harmonised from the national to global levels, and that actions should be taken in order for Member States and the international community to work jointly towards the preparation, improvement and maintenance of fundamental geospatial data themes, building on existing national and regional fundamental datasets (United Nations, 2014e). This need was reinforced by UN-GGIM at its fifth session in 2015 when the Committee of Experts agreed that there was an urgent need for a set of global fundamental geospatial data themes that can be harmonised in order to enable the measurement, monitoring and management of sustainable development in a consistent way over time to facilitate evidence-based decision-making and policymaking, and to work jointly towards a minimum set of fundamental data themes (United Nations, 2015g). These efforts have now been advanced, and at its seventh session in August 2017, UN-GGIM adopted the 14 global fundamental geospatial data themes (Figure 6.4) as a foundation to support global geospatial information management (United Nations, 2017d). However, they now need to be implemented within countries, and African countries in particular.

The 2015 Global Sustainable Development Report dedicated a chapter to ‘New Data Approaches for Monitoring Sustainable Development Progress: The Case of Africa’ focusing on Africa as a continent that has been continuously challenged in the production and use of data in support of its development efforts (GSDR, 2015). While the report provides examples of tapping into Big Data, mobile technologies, satellite data, geospatial information, and their integration, it notes that *“while the lack of consistent up-to-date base mapping – fundamental geographic datasets such as geodetic control, elevation, drainage, transport, land cover, geographic names, land tenure, etc. – across Africa remains a challenge, individual countries are making progress. Tools to share data online have been developed; what is needed now is to make them more widely available. In the short-run countries should be encouraged and supported to improve their national statistical and geospatial web sites, establishing data portals and using existing tools for improving access and use of data”* (GSDR, 2015).



Figure 6.4: The 14 global fundamental geospatial data themes developed and adopted by UN-GGIM (United Nations, 2017d)

It is possible to abstractly consider the high-level national framework in which the NSDI could provide a nation’s sustainable development geospatial requirements. As depicted in Figure 6.5, applying an extended and elaborated set of national fundamental data themes (building directly on the global fundamental geospatial data themes) to contribute as data inputs to the SDGs and targets by means of the global indicator framework, presents both the considerable challenge and opportunity for the national geospatial information agencies.

Maximising the value of fundamental geospatial information to capture elements of the 2030 Agenda is going to be critical to the future development path of many national geospatial information agencies in the coming 5-10 years. For many countries, especially developing countries, sustainable development will provide a tangible policy ‘trigger’ to accelerate the development and adoption of legal and technical geospatial standards; openness and exchange of data and metadata; interoperability of data and information systems; and integration of statistical and geospatial information, including its

management and exchange. In other words, and as discussed in Chapter 8, the 2030 Agenda provides a trigger to accelerate the development and/or expansion of NSDI strategies with commensurate levels of sustainable implementation and maturity. It also provides a strong consensus on the need to integrate the NSDI within national government's (information) development plans. An NSDI implementation strategy that is anchored to sustainable development, as an overarching theme, provides an 'information' approach to national policy. It also brings the analysis and evidence-base to the process, and thereby a consistent monitoring and reporting framework, that would benefit all areas of government, business, the economy and citizen engagement.

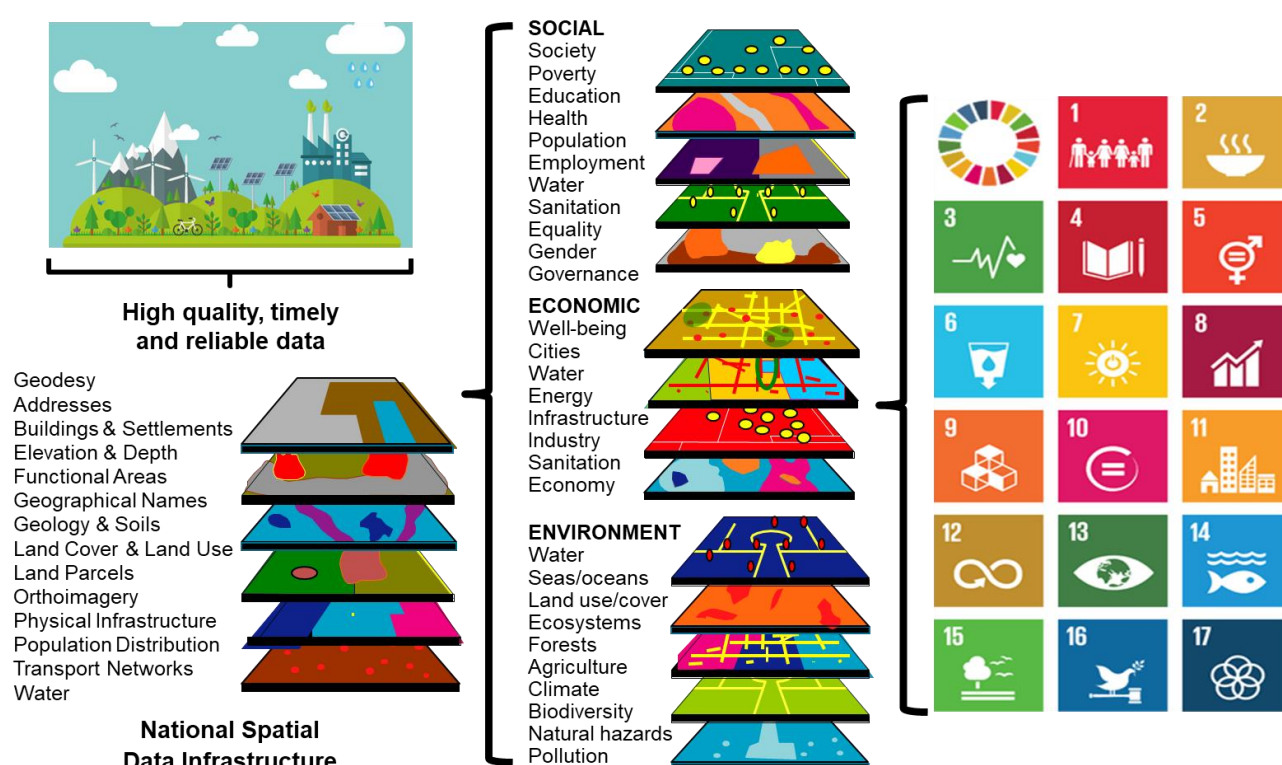


Figure 6.5: Extending fundamental geospatial data themes within the NSDI to accommodate the needs of the SDGs and targets by means of the global indicator framework.

Data, as the basis for evidence-based decision-making and accountability, is proving to be crucial to the success of the 2030 Agenda. The key word here is 'data'. The future of the implementation of the SDGs will in fact be dependent on data, and not whether it is statistical, geospatial, environmental, economic, health, demographic, education, or other data – just data! As is the case with consumers and users in the general community and civil society, it is no longer a necessity for governments and society to know where the data they are using and consuming has come from, or who has generated it. They will just want assurances that it is reliable, authoritative, repeatable, the best available and fit-for-purpose in order to make the right decisions and policy. Within the confines of often inflexible government structures, this is not an easy adjustment and requires the professional communities

(statistical, geospatial, environmental, etc.) to be less domain specific and more ‘integrative data and information systems’ inclusive, which in turn means that much more coordination and collaboration is required across these organisations and governmental structures. This major adjustment sits at the centre of the integrated geospatial information systems framework.

6.4 Chapter Summary

This Chapter discussed the need to integrate geospatial information, statistics, Earth observations and other data sources, as key data sources and requirements to contribute to the measuring and monitoring of the SDGs through the global indicator framework. To achieve this, the Chapter then designs and describes a conceptual integrated geospatial information systems framework as an integrative sustainable development ‘data flow’ that is anchored by the NSDI, providing the underpinning building blocks and processes for countries to measure and monitor the SDGs. The framework is able to organise and integrate data across national information systems, particularly statistical geospatial, and Earth observations, for reporting on the global indicator framework, from local real-world conditions to global harmonised reporting through robust and reliable data inputs. The Chapter then discusses the critical role that future NSDI’s must play in the emerging data ecosystem, providing the integrative platform ‘data flows’ and ‘glue’ for all digital data that has, or can have, a location dimension to it.

The next Chapter designs and describes a national strategic geospatial information framework, a conceptual model, integrative framework and associated tools to guide and enable governments to implement and integrate geospatial information into national sustainable development policy agendas and strategies, and to contribute to country implementations of the 2030 Agenda. A key objective of the framework is to be able to translate global development policy down to national/local implementations through geospatial operating principles and strategic pathways.

Chapter 7 – National Strategic Geospatial Information Framework

7.1 Introduction

Previous Chapters in this dissertation considered and addressed the significant dependencies on geospatial information and emerging technologies, bridging the geospatial digital divide (especially in the African context), and an integrated geospatial information systems framework. While each country has primary responsibility for its own economic and social development, the role of national policies and the existence of development strategies cannot be overemphasised. To bridge the geospatial digital divide, this dissertation has demonstrated that countries will need to develop, strengthen and modernise their approaches to geospatial information management, including aspects relating to geospatial information policies, governance, data-driven integration and infrastructure, education, innovation, use and collaboration. To achieve this in line with the expectations of the 2030 Agenda, countries, through their national governments, need an enabling strategic framework to guide them. A framework that contains all of the necessary elements for its implementation yet is general enough so that countries – all countries, developed and developing – are able to tailor it for their own national circumstances and needs as required.

Chapters 2 and 3 explored the key issues and impediments as to why geospatial information is not more prominent and integrated into sustainable development processes (including at the global level). This Chapter now designs and describes a National Strategic Geospatial Information Framework (Strategic Framework) which can be applied immediately to meet the challenge. The Strategic Framework is for the global geospatial community, and for all countries. It provides a means to bridge the geospatial digital divide, as well as providing a basis and guide for countries to move towards developing and strengthening arrangements in national geospatial information management, and in particular, to meet and overcome complex sustainable development challenges for developing countries.

The Strategic Framework is a deliberate and practical policy approach towards geospatial enablement. It comprises a conceptual high-level model, integrative framework and associated tools. A key objective of the Strategic Framework is to be able to translate global development policy down to national/local implementations through geospatial operating principles, goals and strategic pathways. These elements are combined, in this Chapter to develop the ‘National Strategic Geospatial Information Framework’ as identified in Chapter 1 and illustrated in Figure 1.2.

7.2 Validation for a National Strategic Geospatial Framework for the SDGs

As detailed in Chapter 2, the 2030 Agenda (as do other global development Agendas) captures specific requirements to leverage high quality, timely, reliable and disaggregated data, including Earth observations and geospatial information (United Nations, 2015a). The 2030 Agenda also emphasises that by 2020 developing countries, including the LDCs and SIDS will increase significantly the availability of high-quality, timely and reliable data disaggregated by income, gender, age, race,

ethnicity, migratory status, disability, geographic location and other characteristics relevant in national contexts (United Nations, 2015a). What was not articulated is how the availability of high-quality, timely and reliable data will be realised by 2020 or be applied and integrated into national, regional, or global development approaches.

UN-GGIM (2017a) has noted that the 2030 Agenda demands the need for new data acquisition and integration approaches, including supporting developing countries in strengthening the capacity of national data systems to ensure access to high quality, timely, reliable and disaggregated data. This includes exploiting the contribution that can be achieved through the use of Earth observations and geospatial information, while ensuring national ownership in supporting and tracking progress.

It is now 2020, the 5-year mark of the 2030 Agenda. Since 2016, an annual Sustainable Development Goals Report has been published. As has been documented earlier in this dissertation, each of these annual Reports have echoed the same message; that the world is not on course to achieve the SDG's, and that more and better data is needed to measure and monitor progress. In July 2019, this was reiterated by the United Nations High Level Political Forum on Sustainable Development when the President of ECOSOC noted that *“while the 2030 Agenda and the Goals remain the best road map for overcoming the challenges to ending poverty and achieving sustainable development, a deeper, more ambitious, transformative and integrated response is urgently needed. The international community must move out of its comfort zones to pursue new ways of collective action at a much swifter pace. In particular, investment in data and capacity is needed for adequate measurements to inform policies that ensure no one is left behind”* (United Nations, 2019d, p. 1-2).

At the same time, the global geospatial industry is witnessing unprecedented growth, driving innovation, knowledge, smart solutions, delivery platforms and a location-based information economy. But this geospatial leadership, knowledge and innovation is primarily limited to, and being leveraged by, the developed countries. While technologies are evolving at a rapid rate, the commensurate capabilities, skills and ‘opportunities’ in the developing countries are not. There is still a desperate need for sustained political leadership, resources, commitment, associated frameworks and implementation roadmaps to get access to and exploit the plethora of geospatial data and tools now available to support the implementation of the SDGs. The challenge for countries, is “How can geospatial information be used to underpin future development decision-making in a transparent way, and assist in many aspects of a country’s work including their measuring and monitoring processes?”

It has been the view of this researcher for a number of years⁹ that the global geospatial community still has much work to do in raising awareness of the value and benefits of geospatial

⁹ Dating back to the preparatory discussions that scoped and proposed the formation of a United Nations Committee of Experts on Global Geographic Information in 2009 and 2010: <http://ggim.un.org/meetings/2009-Bangkok/documents/Scoping%20Paper-Greg-Scott-Australia.pdf> and <http://ggim.un.org/meetings/2010-NY/documents/papers/GGIM%20Notes%20GScott.pdf>

information at the policy level, integrating geospatial data across the wider government sector, and establishing new alliances across a much broader and diverse stakeholder community (Scott and Rajabifard, 2015). National policies, geospatial infrastructure, technical capacities and capabilities, need to be developed, better aligned and considerably strengthened so that all countries have the opportunity to develop and contribute to a vibrant national geospatial information ecosystem, and through that, a global and thriving information economy.

To take practical actions to achieve a digital transformation, and to bridge the geospatial digital divide – enabling people, processes, data and technology to implement national policy – requires a strategic policy realisation of the impediments, but in such a way that the actions are able to be integrated into national strategies and arrangements; so that they can be anchored into national development agendas. A national strategic geospatial information framework is able to provide this national guidance for developed and developing countries as they attempt to measure and monitor progress towards the implementation of the SDGs.

This was, and remains, the motivation to define, develop, test and apply a new national strategic framework to enable countries to integrate geospatial information into national sustainable development strategies and processes.

7.3 A National Strategic Geospatial Information Framework

In developing the aim and scope of the Strategic Framework, the researcher formulated a short list of general criteria the Framework should ideally be able to achieve. These were to:

- Accommodate the needs of all countries – developed and developing – and be flexible enough in its design to be able to be adapted and modified to individual jurisdictional needs;
- Inform and contribute to national strategic drivers – including development plans and the SDGs – and enable greater national policy guidance;
- Communicate key messages, encourage leadership, and connect data and technology with people and policy;
- Enable more relevant and targeted data to be generated and utilised, while exploiting accessible and available technologies;
- Support developing countries and regions to achieve their geospatial aspirations in a timely manner through the formulation of appropriate tools and guides which can be piloted, replicated and delivered within and across countries and regions; and
- Establish a broad enabling environment that all countries can both aspire to and implement according to their national situations and priorities, and existing data ecosystems.

The Strategic Framework presents a forward-looking approach that will assist in addressing the understanding and knowledge gaps in sustainable development, and creates an enabling environment where national governments can coordinate, develop, strengthen and promote the efficient and effective

use and sharing of geospatial information for policy formulation and evaluation, decision-making and innovation – and in turn bridge the geospatial digital divide. With strong ownership and leadership by government and other national stakeholders, the Strategic Framework establishes the conditions and processes that enable the sustainability of the data ecosystem, regardless of the various national and sub-national administrative settings and organisational environments that may exist.

Chapter 6 recognised the need for more institutional collaboration, coordination, interoperability and integration across the various national data and information systems that exist; particularly those related to people and place – statistics, administrative, environment, Earth observations, etc. Therefore, a critical recognition is that this is an ‘integrated’ Strategic Framework that is able to support a wide range of societal applications, and which go beyond those that are just geospatially enabled. This is the overarching strength of the Framework – it is integrated and it is holistic and strategic – it is not detailed.

While the previous Chapters of this dissertation explain ‘**why**’ geospatial information management needs to be strengthened and why it is a critical element of a nation’s national priorities and development, the Strategic Framework sets the context of ‘**what**’ and ‘**how**’ change can be made. In this regard, it captures many features that are individually important for countries, recognising that ‘one size does not fit all’ and that the Framework is flexible in its design, able to be adapted and modified as needed. This is key when considering the breadth of the 17 SDGs.

Therefore, the components of the Strategic Framework have been designed and structured to be inclusive, universal and transformational – and have been 10 years in development. As described in Chapter 1 (Section 1.3) the origins of the research problem, and the researcher’s motivation for this dissertation, were initiated in 2010, and related to the researcher’s development of a whole-of-government strategic framework that considered national location information policy, governance, and investment (Scott et al., 2011), but which was never acted upon. That strategic framework was redesigned as a high-level one page UN-GGIM strategic framework in December 2016 by the researcher, and later refined before being adopted by UN-GGIM in August 2017 (UN-GGIM, 2017b). This Strategic Framework was further developed and shaped from those earlier framework concepts, but took on an urgent sense of purpose and relevance in early 2018 after the researcher developed a collaborative partnership between the United Nations and World Bank to progress an overarching geospatial framework to assist developing countries to bridge the geospatial digital divide¹⁰ (detailed in Section 7.4), and founded directly upon this research.

Additional inspiration was provided by the COBIT 5 (ISACA, 2012) management framework. First released in 1996, COBIT (Control Objectives for Information and Related Technologies)

¹⁰ <http://ggim.un.org/meetings/GGIM-committee/7th-Session/documents/UNSD-GSURRE%20Roadmap%20for%20Collaboration-July17.pdf>

comprises five principles to build a holistic framework to help businesses develop, organise and implement strategies around information management and governance. It is an integrative framework that sees information as a key resource for all enterprises, and technology plays a key role. The five principles are: Principle 1: Meeting stakeholder needs; Principle 2: Covering the enterprise end to end; Principle 3: Applying a single integrated framework; Principle 4: Enabling a holistic approach; and Principle 5: Separating governance from management (ISACA, 2012).

To achieve the main objectives of the enterprise, Principle 4: Enabling a holistic approach, captures an interconnected set of seven enablers (Figure 7.1), the first being principles, policies and frameworks. Each enabler needs the input of other enablers to be fully effective (ISACA, 2012). For example: processes need information, and organisational structures need skills and behaviour; and delivers output to the benefit of other enablers, e.g., processes deliver information, skills and behaviour make processes efficient. Importantly, principles, policies and frameworks provide the vehicle to translate the desired behaviour into practical guidance for day-to-day management (ISACA, 2012). This enabling guidance is also able to be applied to the Strategic Framework.

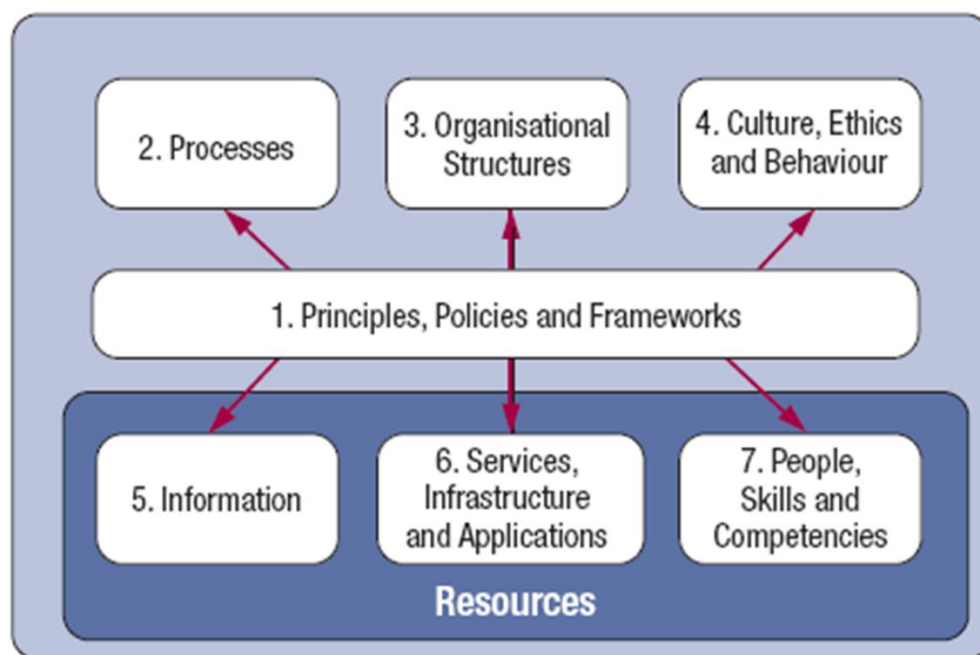


Figure 7.1: The seven enablers of Principle 4: Enabling a holistic approach, of COBIT 5 (ISACA, 2012).

The National Strategic Geospatial Information Framework (Figure 7.2) has been informed by the issues identified in the literature review in Chapters 2 and 3, inputs from Chapters 5 and 6, and developed and validated in close consultation with experts in countries (Chapter 8). Understanding the problems and needs faced by countries, including through workshops, questionnaires and interviews, assisted in validating and updating the Framework.

The Strategic Framework firstly comprises a high-level national policy context, inclusive of a common vision and mission for all national government agencies, **seven underpinning principles** or values, and related national to global strategic drivers. The **eight goals** represent the future state, while the **nine strategic pathways** provide the main ‘actionable implementation’ elements of the Strategic Framework. Achieving the goals will realise the vision, while the strategic pathways outline the key actions that need to be implemented to achieve the goals, outcomes and benefits necessary to support national development. The realised benefits, demonstrating the value and benefits of geospatial information to a nation, are a key element to the Strategic Framework.

The Strategic Framework is structured in this way so that each of these components are able to communicate the intent and purpose of the Framework to key and influential stakeholders – these including groups such as national influencers, political leaders, decision-makers, institutions and organisations within and across government, the business community and academia. In communicating its value, it is important that the Strategic Framework can be seen as aligning with government needs, with national development aspirations, and as an inclusive and engaging mechanism to bring collaboration, coordination and cohesion across a country for the purposes of developing, strengthening and integrating national geospatial information management; and as an evaluation mechanism that can monitor continuous innovation and improvement. Providing a ‘data and information’ approach to policy and implementation will bring the analysis and evidence-base to the decision-making process that will benefit all areas of government and will provide a consistent monitoring and reporting framework for sustainable development within national policy. With this context, the following sections of this Chapter provide further and expanded detail for each of the components of the Strategic Framework as presented in Figure 7.2.

National Strategic Geospatial Information Framework								
NATIONAL POLICY CONTEXT	VISION	<i>The efficient and effective use of geospatial information by all countries to measure, monitor and achieve sustainable social, economic and environmental development – leaving no one behind</i>						
	MISSION	<i>To promote and support innovation and provide the leadership, coordination and standards necessary to deliver integrated geospatial information that can be leveraged to find sustainable solutions for social, economic and environmental development</i>						
	PRINCIPLES (VALUES)	Strategic Enablement	Transparent and Accountable	Reliable, Accessible and Easily Used	Collaboration and Cooperation	Integrative Solutions	Sustainable and Valued	Leadership and Commitment
	STRATEGIC DRIVERS	National Development Agenda • National Strategic Priorities • National Transformation Programme • Community Expectations • Multilateral Trade Agreements • Transforming our World: 2030 Agenda for Sustainable Development • New Urban Agenda • Sendai Framework for Disaster Risk Reduction 2015–2030 • Addis Ababa Action Agenda • Small Island Developing States Accelerated Modalities of Action (SAMOA Pathway) • United Nations Framework Convention on Climate Change (Paris Agreement) • United Nations Oceans Conference: Call for Action • Agenda 2063: The Africa We Want						
GOALS (FUTURE STATE)	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	International Cooperation and Partnerships Leveraged	Enhanced National Engagement and Communication	Enriched Societal Value and Benefits
INFLUENCES	Governance			Technology			People	
STRATEGIC PATHWAYS (WITH KEY ELEMENTS)	Governance and Institutions	Policy and Legal	Financial	Data	Standards	Innovation	Partnerships	Education and Capacity
	Governance model Leadership Institutional arrangements Value proposition	Legislation Policies, norms and guides Data protection, licensing and sharing Responsibility and accountability	Business model Investment Opportunities Benefits realisation	Data themes Data supply chains Custodianship, acquisition and management Data curation and delivery	Quality Technology and data interoperability Community of practice Compliance	Technological advances Innovation and creativity Process improvement Bridging the geospatial digital divide	Cross-sector and interdisciplinary cooperation Community participation Industry partnerships and joint ventures International collaboration	Formal education Awareness raising Professional workplace training Entrepreneurship
BENEFITS (SOCIETAL)	Knowledge Decisions Action Development Society Economy Environment Government Users Citizens Access Technology Applications Value Engagement							
BENEFITS (THEMATIC)	Water Energy Tourism Health Education Infrastructure Security Population Defence Industry Transport Disasters Urbanisation Food Supply Planning							

Figure 7.2: The components of an integrated National Strategic Geospatial Information Framework.

7.3.1 Vision and Mission

The vision and mission statements communicate the overarching aim of the Strategic Framework to stakeholders. The vision statement describes a future state where integrated geospatial information is used to achieve sustainable social, economic and environmental development; while the mission statement is a call to action that will enable governments to achieve the vision.

7.3.1.1 Vision

The efficient and effective use of geospatial information by all countries to measure, monitor and achieve sustainable social, economic and environmental development – leaving no one behind

The vision is that governments and stakeholders are able to achieve sustainable social, economic and environmental development through the efficient and effective use of national and local geospatial information, systems and capabilities for evidence-based policy and decision-making. The vision statement is a future orientated and aspirational declaration of purpose and being. The vision recognises the responsibility for countries to embrace the ambitions of sustainable development, to plan ahead and provide better outcomes for future generations, and to realise our collective aspiration to leave no one behind. Additionally, the vision recognises that any national SDG implementations will be optimised using strategies and frameworks that integrate geospatial information into overall national social, economic and environmental development plans.

7.3.1.2 Mission

To promote and support innovation and provide the leadership, coordination and standards necessary to deliver integrated geospatial information that can be leveraged to find sustainable solutions for social, economic and environmental development

The mission is for countries to promote and support the required innovation, leadership, coordination and standards in order to develop, strengthen, integrate and deliver national geospatial information policy, data, systems, tools, services and capabilities into their national government development policies, strategies and arrangements. The mission is designed to stimulate action towards bridging the geospatial digital divide; to find sustainable solutions for social, economic and environmental development; and to influence inclusive and transformative societal change for all citizens according to national priorities and circumstances.

7.3.2 Principles

In order to anchor the vision and mission to national policy needs, and to the more specific goals, objectives, and priority actions, the Strategic Framework requires an enabling and collaborative environment where government organisations can coordinate, cooperate, and thus improve the management and exchange of national geospatial information to support and serve the national interests of all of its citizens. This enables the value of geospatial information to be realised for national and sustainable development. In order to be effective and avoid duplication of technology and resources,

the Strategic Framework also needs to be cross-cutting across multiple government agencies, and to leverage existing methods and mechanisms as much as possible, for example NSDI capabilities and methodologies; but must also be able to gather and deliver new data and information capabilities not previously considered.

Therefore, the Strategic Framework contains seven principles or values. These principles were initially developed by the researcher from September 2016 to February 2018 as an outcome of the literature review and issues identified in the earlier Chapters. They were refined as necessary during the subsequent workshops and consultation with African countries. The principles represent the key characteristics and values that are to be used by countries as a guide and reference point when implementing the Framework. How these principles are applied will depend on the implementation approach adopted by each country. This because the principles are simply the generic compass for supporting and implementing associated policies and frameworks, but allow for methods to be tailored to individual country needs and circumstances as required. The principles reflect what is important for success (i.e. the vision statement), and frame the outcomes to be delivered through the strategic pathways, as per the mission statement.

While it is acknowledged that these principles are not exhaustive and will change over time, adherence to such a set of principles will make complex collaboration possible among multiple agencies, allow the integration of national information systems, and will deliver consistent geospatial information management, resulting in more open, accountable, responsive, and efficient government. The seven principles that underpin the Strategic Framework are detailed in Table 7.1. They include concepts that focus on a country's geospatial capabilities broadly being: strategic, accountable, reliable, collaborative, integrative, sustainable, and committed.

PRINCIPLE 1 Strategic Enablement	The implementation of the Strategic Framework requires political and financial support to be fully 'enabled' and should therefore align with and support government's strategic directions on issues such as economic growth, social well-being, job creation, poverty reduction, natural resource monitoring, and environmental management and preservation.
PRINCIPLE 2 Transparent and Accountable	Government geospatial information is developed and shared according to key accountability and transparency guidelines so that all citizens, government agencies, academia and the private sector have access to this valuable and underpinning national information resource.
PRINCIPLE 3 Reliable, Accessible and Easily Used	Geospatial information is reliable and authoritative, and made accessible and usable so that it can be leveraged for decision-making, research and development, used to stimulate innovation, and to support the creation of sustainable services and products to advance social, economic and environmental development.
PRINCIPLE 4 Collaboration and Cooperation	Collaboration and cooperation (between government, business, academia, civil society and donors) are factored into the implementation of the Strategic Framework to strengthen information-sharing between providers and users, reduce duplication of effort across the government sector, make for a robust information system, as well as providing coordination and clarity on roles and responsibilities.

PRINCIPLE 5 Integrative Solutions	The implementation of the Strategic Framework is to be integrative in nature – and consider how people, organisations, systems, and policy and legal structures work together to form an effective and holistic system-of-systems for managing geospatial information and its use within the data ecosystem.
PRINCIPLE 6 Sustainable and Valued	The implementation of the Strategic Framework will be conducted in such a way that it enhances national efficiency and productivity; is enduring and sustainable in the long term; and is deployed in a way that provides improved and valued government services to citizens.
PRINCIPLE 7 Leadership and Commitment	Importantly, the implementation of the Strategic Framework will require strong leadership and commitment, often at the highest level, to enhance the long-term value of investments in geospatial information. This will be achieved through careful analysis, prioritisation and sequencing to develop an action plan that carefully applies interventions in the short, medium and long-term, and that can receive high-level endorsement and support by government.

Table 7.1: The seven Principles of the National Strategic Geospatial Information Framework.

7.3.3 Strategic Drivers

The strategic drivers are ‘drivers for change’ and aligned to the National Policy Context¹¹ of the day. They will vary from country to country based on national priorities and objectives, strategic government alignments, and community expectations. They are not exhaustive and will change over time, hence they are not static, and are provided in the Framework as an initial set of global to national strategic high-level drivers for change.

With regard to the global development Agendas, many countries understand that the 2030 Agenda also captures specific and separate global United Nations system outcomes as described in Chapter 2 (Section 2.2.8). All countries have aligned their national priorities and development outcomes to at least one of these global Agendas. However, there are some additional regional strategic priorities that groupings of countries will need to consider. For example, all African countries are intrinsically aligned to ‘Agenda 2063: The Africa We Want’¹² which must be recognised within the National Policy Context for all African countries. These then cascade down to the national development drivers and strategic priorities that may also include national transformation programmes, multilateral trade agreements, and even community and societal expectations on government. The Strategic Framework, to be enduring, must be aligned to each country’s national strategies, development priorities, drivers and circumstances.

7.3.4 Goals

To achieve the overarching vision, the Strategic Framework identifies eight aspirational goals. As with the principles, the research in the earlier Chapters have provided the basis and foundation for

¹¹ For the purpose of the Strategic Framework, the National Policy Context relates to the broad course of action or statements of guidance adopted by the government at the national level in pursuit of national objectives.

¹² Agenda 2063 is Africa’s blueprint and master plan for transforming Africa into the global powerhouse of the future. It is the continent’s strategic framework that aims to deliver on its goal for inclusive and sustainable development. <https://au.int/en/agenda2063/overview>

the goals. The progressive achievement of these goals will move countries towards a future state where they have the capacity and skills to organise, manage, curate and leverage geospatial information to advance government policy and decision-making capabilities, bridge the geospatial digital divide, influence inclusive and transformative societal change, achieve economic prosperity and social development, and ensure effective environmental management. The eight goals of the Framework, also developed by the researcher from September 2017 to February 2018 and refined as necessary during the subsequent workshops and consultation with African countries, articulate what needs to be achieved (but not how) and are detailed in Table 7.2.

GOAL 1 Effective Geospatial Information Management	Enabling geospatial information governance, policy and institutional arrangements that ensure effective geospatial information management, accommodate individual organisational requirements and arrangements, and that are aligned to national and regional priorities, and global policy frameworks.
GOAL 2 Increased Capacity, Capability and Knowledge Transfer	Mechanisms are established to raise awareness of the value and use of geospatial information, promote capacity and capability, and build an inventive and resourceful mind-set across government, industry, academia, and the private and community sectors.
GOAL 3 Integrated Geospatial Information Systems and Services	Geospatial information, including community information, is integrated and accessible as a national information system-of-systems and services across the government sector and maximised for evidence-based policy and decision-making. The Integrated Geospatial Information Systems Framework (Chapter 6), anchored by the NSDI, facilitates these processes.
GOAL 4 Economic Return on Investment	An economic return on investment, and other often intangible socio-economic benefits, is realised through best practice management, and the exploitation and innovative use of integrated geospatial information. Provides a means to account for the costs associated with all aspects of a national geospatial information program and the socio-economic value and realised benefits that result from these costs and investment.
GOAL 5 Sustainable Education and Training Programs	Education and training programs are established to grow the number of professionals in the fields of geography, data science and geospatial information technology, and to develop specialist skills related to geospatial financial systems, policy and law, and project management.
GOAL 6 International Cooperation and Partnerships Leveraged	International cooperation and partnerships are leveraged and sustained in a way that fosters the management and exchange of geospatial information in support of national development interests. For developing countries, these mechanisms increase development capacity, enhance organisational knowledge and collaboration, and empower creativity and innovation.
GOAL 7 Enhanced National Engagement and Communication	All stakeholder groups, and specifically high-level decision-makers and champions, understand and are fully engaged in the value of integrated geospatial information for decision-making and socio-economic development. This creates a greater sense of trust in geospatial information, and in the organisations that provide it.
GOAL 8 Enriched Societal Value and Benefits	Social and economic development, and environmental sustainability, is enriched through increased levels of use of integrated geospatial information products and services. Drivers demonstrating the value and benefits of geospatial information include the global development Agendas, transforming government, community expectations, and bridging the geospatial digital divide.

Table 7.2: The eight Goals of the National Strategic Geospatial Information Framework.

7.3.5 Strategic Pathways

The Strategic Framework is anchored by and implemented through nine strategic pathways. The objective of the strategic pathways is to provide the ‘**what**’ and ‘**how**’, of the implementation roadmap to guide governments towards taking actions to design, plan, establish, implement and maintain national geospatial information systems in a way that will deliver a vision for sustainable social, economic and environmental development. The strategic pathways have been developed to reflect all the component parts of an integrated national geospatial information program. For emphasis on how they are arranged and interact, Figure 7.3 provides a three-by-three matrix of each strategic pathway and colour coded by influence and relationships. The strategic pathways are first organised laterally in response to three principal areas of equally shared influence: these being aspects related to overarching national **Governance**; the underlying data and enabling **Technology**; and the importance of **People** in the geospatial information life cycle.

- **Governance** influences strategic pathways: 1. Governance and Institutions; 2. Policy and Legal; and 3. Financial. Governance is essential to achieving any nationally integrated geospatial information management capability. The NSDI journey has demonstrated this fundamental necessity for good geospatial governance, and the consequences of not having it, for many countries over the past 20 years (Chapter 3). Governance includes the institutional arrangements, policy and legal requirements, and financial concerns that need to be factored into any sustainable geospatial information program or project.
- **Technology** influences strategic pathways: 4. Data; 5. Standards; and 6. Innovation. Chapters 3 and 5 demonstrated how much technology, including digital transformation and disruption, now influences geospatial location data, innovations, the required standards, and what can be achieved with the emerging geospatial data ecosystem that is able to respond to continually evolving needs, demands, and uses.
- **People** influences strategic pathways: 7. Partnerships; 8. Education and Capacity; and 9. Communication and Engagement. People are arguably the most important component, as people are the Strategic Framework enablers – performing all the tasks needed for a successful geospatial information program – often through partnerships and in collaboration with others. Having the necessary skills and knowledge is crucial, requiring education and capacity programs, and ongoing communication and engagement.

With reference to the discussions in Section 3.7 in Chapter 3 and Section 6.3 in Chapter 6 regarding, firstly the NSDI evolution and foundations, then the limitations of first and second generation NSDI approaches, to the future critical role of NSDI’s in the data ecosystem, it is important to note that the strategic pathways consider these aspects. The Strategic Framework, through the strategic pathways, is directly relevant to, and able to readily leverage and build upon, existing NSDI information architectures, capabilities and methodologies – irrespective of their level of development or maturity.

The strategic pathways are therefore structured in such a way so that they represent three levels of enabling geospatial (NSDI) capability vertically (Figure 7.2). Level 1 capability (Governance and Institutions, Data, and Partnerships) broadly aligns with the requirements for a typical initial NSDI implementation. Level 2 (Policy and Legal, Standards, and Education and Capacity) represents what would typically be seen as the ‘enablers’ for an advanced and mature NSDI implementation. Level 3 (Financial, Innovation, and Communication and Engagement) represents the NSDI future state as an integrated ‘on-demand’ information knowledge infrastructure, in which organisations are able to gather and deliver, sustain and communicate new data and integrated information capabilities not previously considered. With key components – such as the governance and institutional arrangements, roles and responsibilities, the very existence of a Strategic Framework, funding models and the legal and regulatory framework – established, it is at this level of maturity that the long-term sustainability and benefits of open data, machine readable data, semantic web technologies and linked data will be realised.

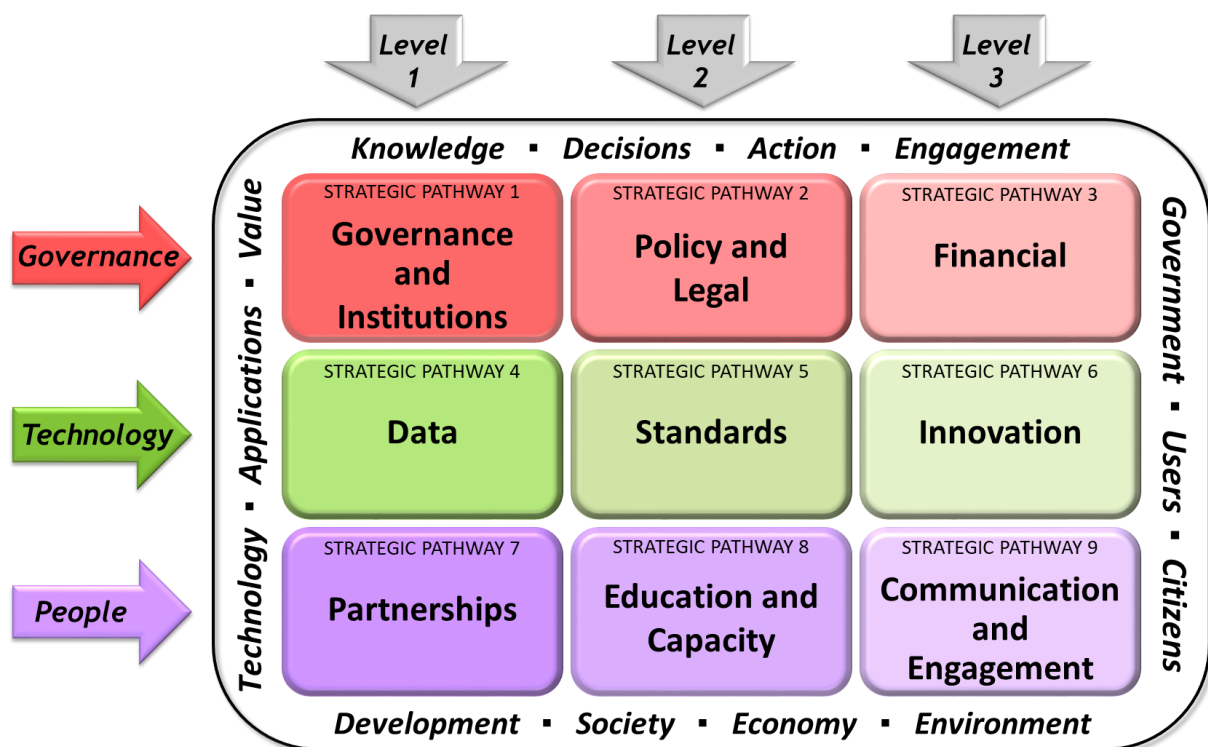


Figure 7.3: The nine integrated strategic pathways of the National Strategic Geospatial Information Framework.

For many countries, initiating the development of a national geospatial program can be a daunting task, and will often need to be addressed in a staged approach. In recognition of this, a key strength to the nine strategic pathways is that they each have their own purpose and objectives, and are presented with separate key elements in Section 7.3.6. In their Strategic Framework implementation process, developing countries in particular may have limited skills and/or resources available to them, and may have desires to identify and address a single strategic pathway at a time. While this is not ideal,

a strength to the Strategic Framework is that there are many aspects and dimensions to each individual pathway which can be addressed by countries. However, it is intended that, when all nine strategic pathways are completed and are holistically united as one, the Strategic Framework is connected, integrated and able to be fully implemented.

This ‘integrative’ nature of the Strategic Framework cannot be overemphasised. The notion of the strategic pathways being integrated implies that they have to be equal and balanced at the end of the day. Each strategic pathway cannot stand on its own without a relationship to the other pathways. One strategic pathway is not more important than another pathway – although they are all unique in their nature. It is the relationships and linking of all of the pathways that establishes the integration. Focussing on one pathway on its own is a means to reverting to outdated silo thinking and concepts. The overarching comprehensiveness is what is important, as it is a ‘strategic’ Framework. The Framework is the integration, not the individual key elements themselves. The strategic pathways are the means to achieve the goals of the Framework.

7.3.6 Key Elements of the Strategic Pathways

In order for the strategic pathways to provide the necessary level of detail and guidance for countries to take actions, each pathway is explained and expanded in some detail below. These then form the basis for the more detailed specifics and actions to be taken in implementing the Framework. As identified in Figure 7.2, each strategic pathway contains four key elements as the enabling components or requirements for the strategic pathway to be implemented. The key elements are a derivative of the pathways at a lower level of detail, and are intended to enable concepts to be more concrete and understandable for countries. While they were originally conceived during a dedicated write-shop meeting organised by the researcher with six global experts¹³ in May 2018, the strategic pathways and key elements have been developed and refined iteratively in consultation with African countries through a series of consultations and workshops (as described in Chapter 8) and the global geospatial community (as described in Section 7.4 in this Chapter).

The strategic pathways and their key elements are at the heart of the actions that are taken for the national implementation of the Strategic Framework. The aim of each pathway is to achieve these four key elements, which must be considered when making decisions and planning ‘what’ key strategically-aligned actions are to be included in the Strategic Framework, support the vision, and are able to be cascaded throughout the organisational culture. This section elaborates on each of the four key elements for the nine strategic pathways; which comprise 36 key elements.

By way of structure and description, a summary of the four elements is first provided in a boxed section for each strategic pathway (Box 7.1 to Box 7.9), followed by a more detailed description of the

¹³ Dr. Lesley Arnold, Mr. John Kedar, Mr. Kevin Pomfret, Mr. Teo, CheeHai, Mr. Peter ter Haar, and Mr. Timothy Trainor.

components of each element. Step-by-step actions for how each of the strategic pathways and their key elements are operationalised within a country are not described, and are beyond the aims and objectives of this dissertation. However, Chapter 8 provides an initial example of how this may be applied via the case study for Ethiopia.

7.3.6.1 Strategic Pathway 1: Governance and Institutions



Box 7.1: A summary of the four key elements of Strategic Pathway 1: Governance and Institutions.

7.3.6.1.1 Governance model

Good governance provides the foundation for the operating structure and implementation of the Strategic Framework for a country, and to ensure that the vision and mission are achieved. The full realisation of the SDGs depends on a common understanding of the basic principles of good and effective governance (Bouckaert et al., 2018). The governance model establishes accountability, clarity, trust, oversight, and most importantly – leadership. It defines the way geospatial information responsibilities, roles and resources are assigned, coordinated, structured, managed and monitored within and across national organisations and institutions. A critical consideration in the governance model (and to overcome any existing fragmented and/or stove-piped structural arrangements) is the designation of a lead organisation that is primarily responsible for geospatial information management within a country. For example, the national geospatial or mapping authorities, military mapping units within the national defence force, or agencies responsible for the NSDI.

The governance model directs the level of geospatial information coordination across government – ideally with all levels of government – through partnerships of government entities (at local, national, regional and global levels), private sector, academia and/or NGOs. It reflects the interrelated relationships and operational dynamics that influence the management of geospatial information, and provides the policies, guidelines and measures to effectively collect, manage, share, curate and leverage geospatial information. A governance model is essential to achieving government objectives, driving improvement and maintaining a legal and ethical standing in the eyes of stakeholders, partners, regulators and the broader community. It ensures that the geospatial data needed for a country's current operations and future planning are considered and recognised, along with the technology and standards that are required to achieve the outcomes. The model adopted should meet key accountability and outcome provisions of individual government departments, as well as balancing the need for effective collaboration across institutions to achieve the best outcome from a whole-of-government perspective.

7.3.6.1.2 Leadership

While much of the literature focusses on prevailing governance and institutional issues that impede the sharing of geospatial information, it ignores the key roles of individuals and leadership, those with the vision and motivation to adopt and drive change (Craig, 2005). Leadership is required to realise the implementation of a national Strategic Framework that clearly describes the country's strategic priorities and how geospatial information can be applied to address these priorities. Leadership is also about delivering on the vision, the capacity to take positive steps, trust, and knowing the tactics to achieve the vision. With strong leadership, anything is possible; without leadership, very little is achievable. Through leadership the Strategic Framework answers the question – Where are we going? It paints a vision of a future where the implementation of the Framework is realising significant national social, economic and environmental benefits. Having this vision builds momentum among stakeholders and partners to take action and achieve results.

A high-level 'champion' in government is typically identified to actively lead, engage and promote the strengthening of geospatial information management across government organisations (at a local, national and global level), and with industry, the private sector, academia, and the local community. An important first step in forming the leadership is to institutionalise the establishment of a governing board, council, advisory body, steering committee, or similar leadership mechanism. This provides the necessary leadership and direction for anchoring, implementing and sustaining the Strategic Framework (Othman and Rahman, 2014).

7.3.6.1.3 Institutional arrangements

In the context of geospatial information, institutional arrangements can be defined as those formal and informal cooperation structures that aim to enhance, frame or regulate the voluntary or forced alignment of tasks and efforts of organisations in the pursuit of geospatial information

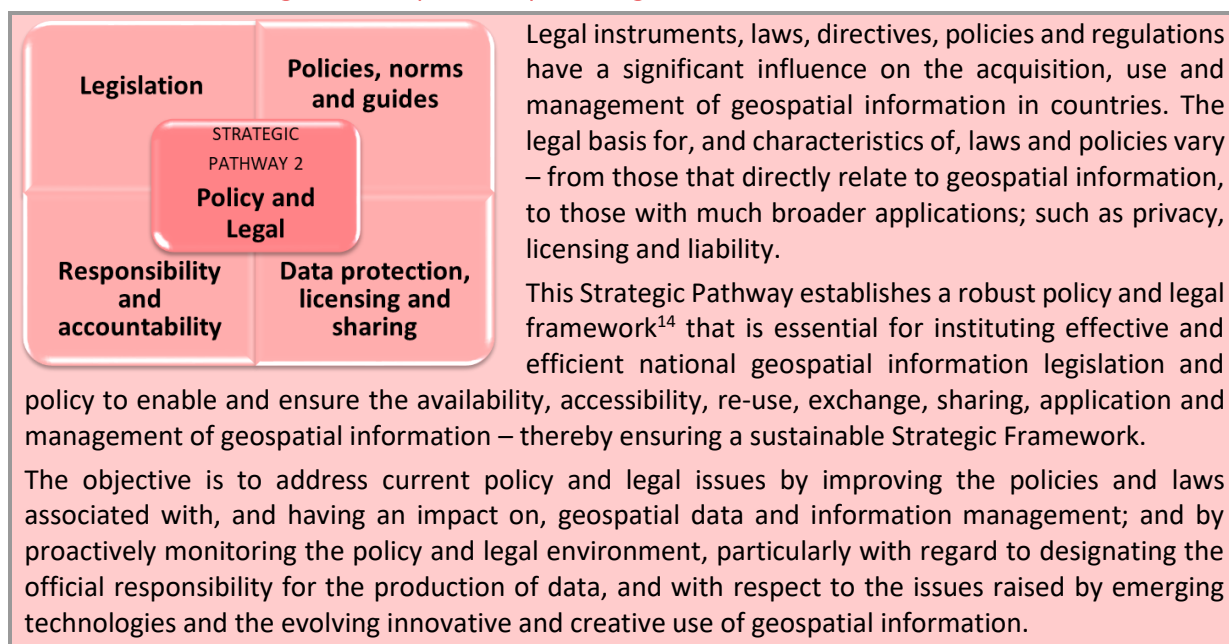
management. With an emphasis on coordination, they support and link public and private institutions and/or organisations to fulfil their mandate (Crompvoets and Ho, 2019). Appropriate institutional arrangements should be included in the roles and responsibilities of geospatial organisations, from the identification of data sources through to the dissemination of outputs and services, and an authoritative, reliable and sustainable geospatial information base for all users. They also provide the operating relationship between organisations - producers, administrators and/or users of geospatial information. Organisations need to be adequately enabled and mandated to acquire, administer, manage and deliver operations associated with geospatial information and decision-making over the longer term. Therefore, sound policies and legal mechanisms assist in strengthening institutional arrangements.

7.3.6.1.4 Value proposition

The geospatial information value proposition is key to achieving political support. There are many benefits that geospatial information delivers to support the mandates, priorities and responsibilities of government – the benefits of which are ultimately realised by the community. However, the value proposition – understanding the costs (economic, social and environmental) and subsequent benefits to the public sector and the community – is not always clear (Janssen, 2009). The value proposition is an important part of the Strategic Framework. It answers 'why' integrated geospatial information is a valuable government asset.

The value proposition is the means to raise awareness, open the political debate, and convince decision-makers of the importance of investing in geospatial data and the technologies that enable information sharing, and improved government services and products. Importantly, the value proposition explains 'why' having integrated geospatial information will be of more value than just continuing to manage data in the same ways it has been – including in traditional, often stove-piped, NSDIs. Understanding and communicating the value proposition, in a country's specific context, is key to achieving political and management buy-in, financial support, human resources, and sustainability (Kruse et al., 2017).

7.3.6.2 Strategic Pathway 2: Policy and Legal



Box 7.2: A summary of the four key elements of Strategic Pathway 2: Policy and Legal.

7.3.6.2.1 Legislation

Legislation comprises the legal instruments, laws and regulations that provide the coherent legal framework within which geospatial policies must operate. These laws and regulations may be specific to geospatial information or closely related. Legislation or laws refer to an enforcing feature of a policy and legal framework that are binding. Other equivalent terms that are used that have essentially the same meaning include decrees, orders, codes, ordinances and regulations. As public bodies are often the sole or at least the most important supplier of certain geospatial data, this might translate into a dominant position or a monopoly in competition law terms. Hence, national competition law may also be an undercurrent in the legal framework for public sector geospatial data (Janssen, 2009).

For the purposes of this strategic pathway, the term ‘legislation’ or ‘law’ apply to all of these types of legal instruments (UN-GGIM, 2019c). Legislation and laws may be specific to geospatial information (such as legislation on geospatial data access, re-use and sharing) or closely related (i.e. privacy, liability, (national) security, intellectual property rights management). Although laws can be generated or created in a number of different ways, each have several similarities including, having force and thus helping create compliance, taking a long time to create and a long time to amend or change. Further, the types of use of the data, intended or otherwise, also influences which legislation

¹⁴ Building upon the work of the UN-GGIM Working Group on Legal and Policy Frameworks for Geospatial Information Management: http://ggim.un.org/documents/E-C20-2018-9-Add_2-Compendium-on-Licensing-of-Geospatial-Information.pdf and http://ggim.un.org/meetings/GGIM-committee/9th-Session/documents/E-C.20-2020-13-Add_1_Legal_and_Policy_Frameworks_Implementation_Guidance.pdf

and rules are to be applied by bodies making the data available and by users requesting the data (Janssen, 2009).

7.3.6.2.2 Policies, norms and guides

Policies, executive orders, administrative measures, norms and guides are not enforceable under law, but have an important role in geospatial information management and use (UN-GGIM, 2019c). They often tend to be aspirational, non-binding features of a policy and legal framework. Norms, policies and guides are useful because they are relatively easy to publish, and they can be changed or updated easily. However, they do not have the force of law and can be difficult to enforce. One of the primary benefits of policies, norms and guides is that they are much easier to develop and implement than laws and regulations, and are therefore more flexible, which makes them easier for adoption. They can also remain in force longer than an agreement and can apply to both the public and private sectors. In addition, they are the easiest to modify to adapt to new technologies or legal issues that may arise (UN-GGIM, 2019c). However, since policies, norms and guides are non-binding, they generally cannot be enforced in a court of law (Bodansky, 2015).

7.3.6.2.3 Data protection, licensing and sharing

Legal conditions such as data protection and licensing agreements impact the flow, sharing and use of geospatial information. Many of these are addressed as part of a country's broader policy and legal framework through contracts, agreements, data-sharing agreements or licenses. However, the arrangements will always remain subject to the applicable policy and legal framework of the country, including (particularly for governments), downstream third party copyright in data products generated, and to the extent which intellectual property rights subsist in such data sets (Judge and Scassa, 2010). Contracts and other forms of agreements between parties can enable a fuller utilisation of geospatial information, but it is not always realised that most of these agreements are legally enforceable, and may not address data quality concerns.

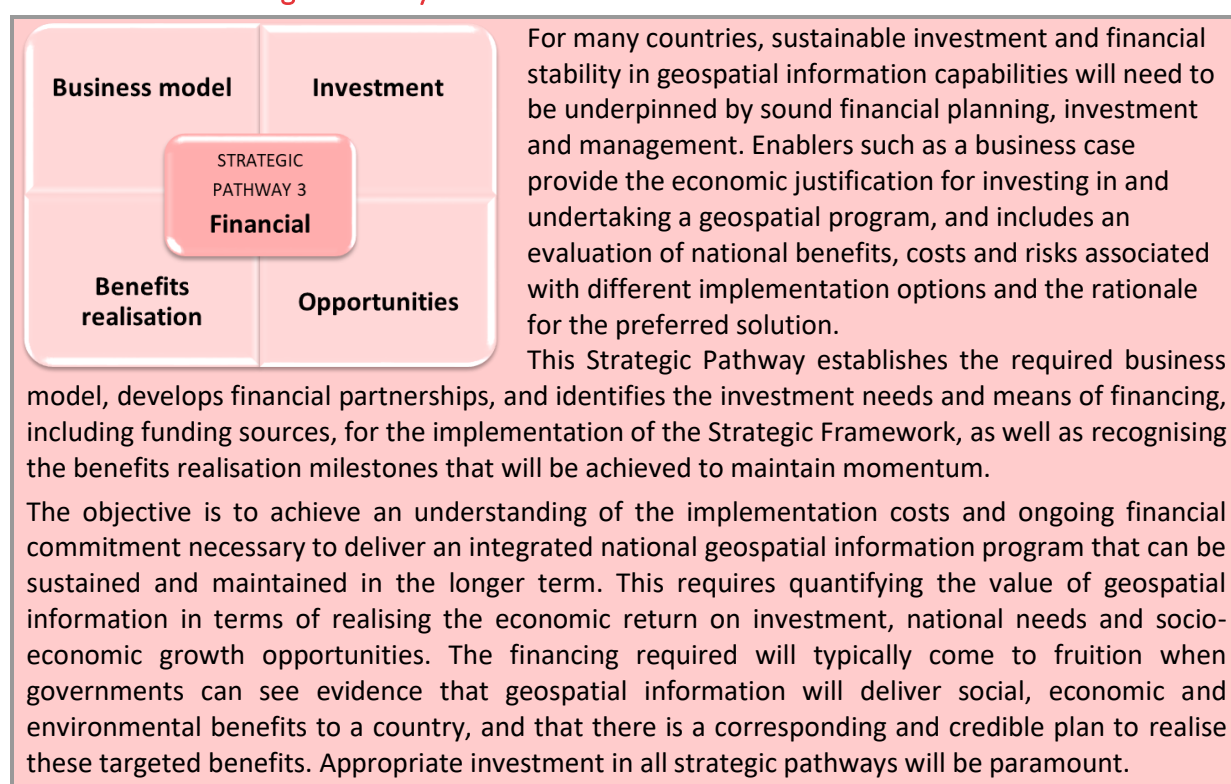
While there are several benefits to using an agreement to address legal issues that restrict or limit geospatial data access, use and sharing (UN-GGIM, 2019c), there is a growing trend by governments towards open data and the use of open licenses, and representing a significant change in who can access government data, and under what terms. Given the increasing pressure on the release of location-based open data, methods need to be in place for the anonymisation or aggregation of data to protect privacy, as well as conducting necessary privacy, security, and risk assessments (Cavoukian et al., 2010; Johnson, et al., 2017).

7.3.6.2.4 Responsibility and accountability

Responsibility and accountability is required to lead and monitor the development of appropriate laws and policies, and to ensure a sound and enabling policy and legal environment for widest possible application of geospatial information for transformational and sustainable societal,

environmental and economic benefits. Regarding the laws and policies in themselves, there will be a need to provide the compliance mechanisms for effective and efficient integrated geospatial information management. This may require a specific organisation(s) to be responsible for implementing and sustaining the policy and legal aspects of the Strategic Framework. Then, there is the collection, production and provision of geospatial information, and whether this may be limited to certain approved entities. For example, national geospatial or mapping authorities, military mapping units within the national defence force, or commercial operations. A further consideration is appropriate financing, not only to collect geospatial data but also for its maintenance, storage and making it available to third parties. These aspects will need to work together in enabling good leadership, responsibility and accountability (UN-GGIM, 2019c).

7.3.6.3 Strategic Pathway 3: Financial



Box 7.3: A summary of the four key elements of Strategic Pathway 3: Financial.

7.3.6.3.1 Business model

A business model describes the rationale for how a government (or an organisation) creates, delivers and captures value in economic, social and other contexts, and is influenced by policy and fiscal governance (Wirtz et al, 2016). Underpinned by a series of value propositions, a business model identifies the sources of revenue, the intended customer base, products, and details of financing. Typically operating at two levels – at a whole-of-government level and at an organisational level – the whole-of-government business model sets the government’s fiscal agenda and funding capabilities, which will typically dictate the business model at an organisational level.

Within this strategic pathway, the business model captures the fundamental assumptions relating to the environment within which national geospatial information management and capabilities will operate. With government financing, the value of investment in geospatial information can typically be viewed as benefits to economic, social and environmental program outcomes. The business model identifies the sources of revenue, products and services to be offered, the intended customer base, financial commitments, stakeholder contributions, expected benefits and details of financing opportunities. While government is not typically a commercial operation, employing the practices of business management, particularly in regard to the creation of a business case, finance plan, procurement and project management, significantly aid government in effectively planning for and managing geospatial information programs.

7.3.6.3.2 Investment

The acquisition, provision and management of geospatial information comes at a cost; and the more detailed the information provided, the more the cost. However, the cost and value of geospatial information is often very difficult to quantify financially and politically, especially as it is often seen as a national ‘public good’ commodity to society. This is even more important to developing countries that have very limited financial resources. Understanding the investment, including the economic viability and return on the investment (including funding), and other often intangible socio-economic benefits, provides a means to account for the cost-benefits and effectiveness associated with all aspects of a national geospatial information program, and the socio-economic value and realised benefits that result from these costs and investment (Giff and Coleman, 2002; Cellini and Kee, 2010).

The range of approaches to investing in and financing, including the sources and means of financing, the development of a national geospatial program are varied, with several approaches that countries can apply to meet their needs. The choice may primarily be influenced by fiscal policy and accountability, other policy frameworks and regulations imposed by governments, institutional arrangements and relationships, as well as the maturity of the geospatial information markets and associated suppliers of products and services. Sources of funding may include government provided allocations, loans or grants from international financing institutions, or from donor countries, public-private partnerships and portions of fees collected from products that are returned to the organisation for operating expenses (FGDC, 2016).

7.3.6.3.3 Opportunities

While investment and financing opportunities may exist in different guises, it is not always easy to know they exist, nor see these opportunities for what they are. There are techniques for aligning national geospatial requirements and use cases with national policy objectives and strategic programs in order to trigger investment opportunities in geospatial information management. This is one of the main objectives of the Strategic Framework. For example, a strategic alignment with the priorities of government may in turn provide the opportunities for additional and/or new funding to support these

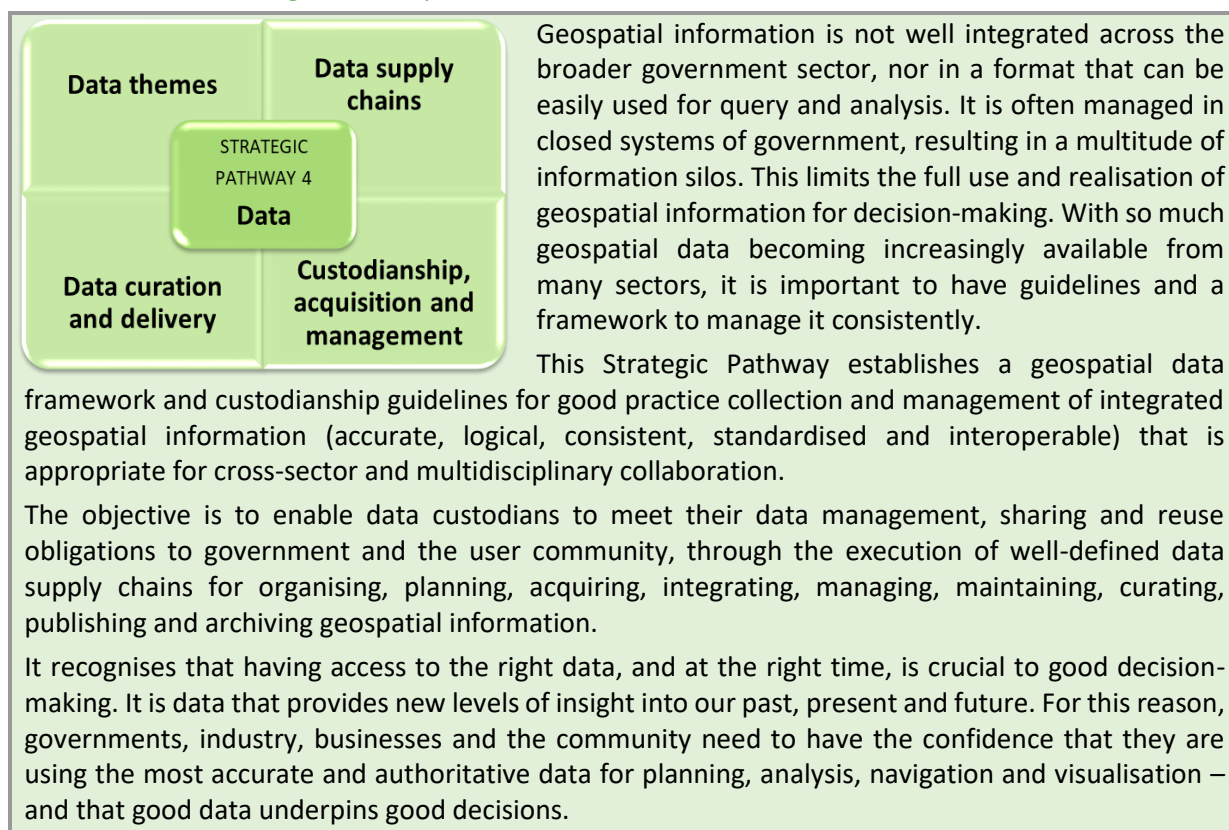
activities from a geospatial perspective. For example, a land administration reform project is an opportunity to improve the accuracy of the cadastre, and a disaster preparedness project is an opportunity to capture building footprints and integrate them with household data. In these examples, the geospatial-related components of these national priorities contribute to the Strategic Framework and national geospatial information program as a whole.

Further, due to growing limitations in budgets and staff resources within government, interest in collaboration between different sectors of society, such as public-private partnerships, are growing. The private sector often responds to market trends more quickly, taking advantage of opportunities and the value-added benefits to the geospatial information made available. Having a strategic business case that includes stakeholders and partners, aligned to national objectives, for how and when the different aspects of the geospatial program are implemented, clearly shows the need for funding, as well as how the funds are allocated and dispersed in meeting the financial demands of the program.

7.3.6.3.4 Benefits realisation

The importance of realising benefits from geospatial information has been acknowledged by the information systems and technology communities for many years. Benefits are often dependent on change processes, often resulting in organisational change, over the life cycle of a project or program. A common understanding of benefits realisation is the process of organising and managing such that the potential benefits arising from the use of information and technology are actually realised (Flak and Solli-Saether, 2013). Benefits realisation is often considered as a multiple-step process. At a high level, it involves: (1) Benefits planning – realising benefits needs to be carefully planned and managed, including the long-term value of the benefits; (2) Benefits delivery – organisations will only be able to deliver value if they can develop a benefits delivery competence and organisational change necessary to realise all of the benefits specified in the benefits realisation plan; (3) Benefits review – organisations must be able to effectively monitor and assess the success of the project in terms of potential benefits, the delivered benefits, and the identification of ways and means by which further benefits might be realised; and (4) Benefits exploitation – once a project is implemented the full potential is often not realised until after it is fully operational, stakeholders have become experienced in its use, and associated organisational change is realised (Ashurst et al., 2008). While benefits realisation may appear daunting, efforts at determining benefits help in justifying the sustainability of the geospatial information program. Hence, benefits are a key element to the Strategic Framework, and should communicate the benefits from the investment; the socio-economic value of geospatial information and the necessary levels of investment and sources required to deliver this value.

7.3.6.4 Strategic Pathway 4: Data



Box 7.4: A summary of the four key elements of Strategic Pathway 4: Data.

7.3.6.4.1 Data themes

All governments and users have a recurring need for fundamental geospatial data themes, as well as additional application-specific and socio-economic themes. National priority and fundamental geospatial data themes, and the datasets that fall within each of these themes, are relevant to a broad range of applications, including the SDGs. As discussed in Chapter 6, (Section 6.3.2) this need was recognised by UN-GGIM in developing and adopting the Global Fundamental Geospatial Data Themes to support global geospatial information management. All countries are encouraged to use and adopt these 14 data themes, which can be adapted to align with national strategic and statutory needs and mandates. In addition, the data themes can include additional application data themes that are captured for a specific purpose, such as health and utilities; and socio-economic themes that are used for demographic studies.

7.3.6.4.2 Data supply chains

The management of data streams, and the integration and use of data from internal and external sources can be achieved through data supply chain concepts (Spanaki et al., 2016). The data supply chain is a life cycle for data, in this case providing the flow of geospatial information from one organisation to another. In a supply chain, organisations are referred to as supply chain nodes, and information flows are referred to as supply chain links. Each organisation (node) will typically add

value, such as updates, to the data before transferring the information on to the next organisation (node) for additional use and/or value-add (Arnold, 2016). At each value-add point in the chain there may be heterogeneous geo-processes, methods, models and workflows combining to generate, modify and consume geospatial data (Varadharajulu et al., 2015). Common types of interlinkages for geospatial information flows are those between: one level of government and another, such as between national and sub-national levels; organisations at the same level of government, such as between the geospatial organisation and statistical organisation; agencies/departments and volunteer geographic information providers and various projects; and agencies/departments and private companies.

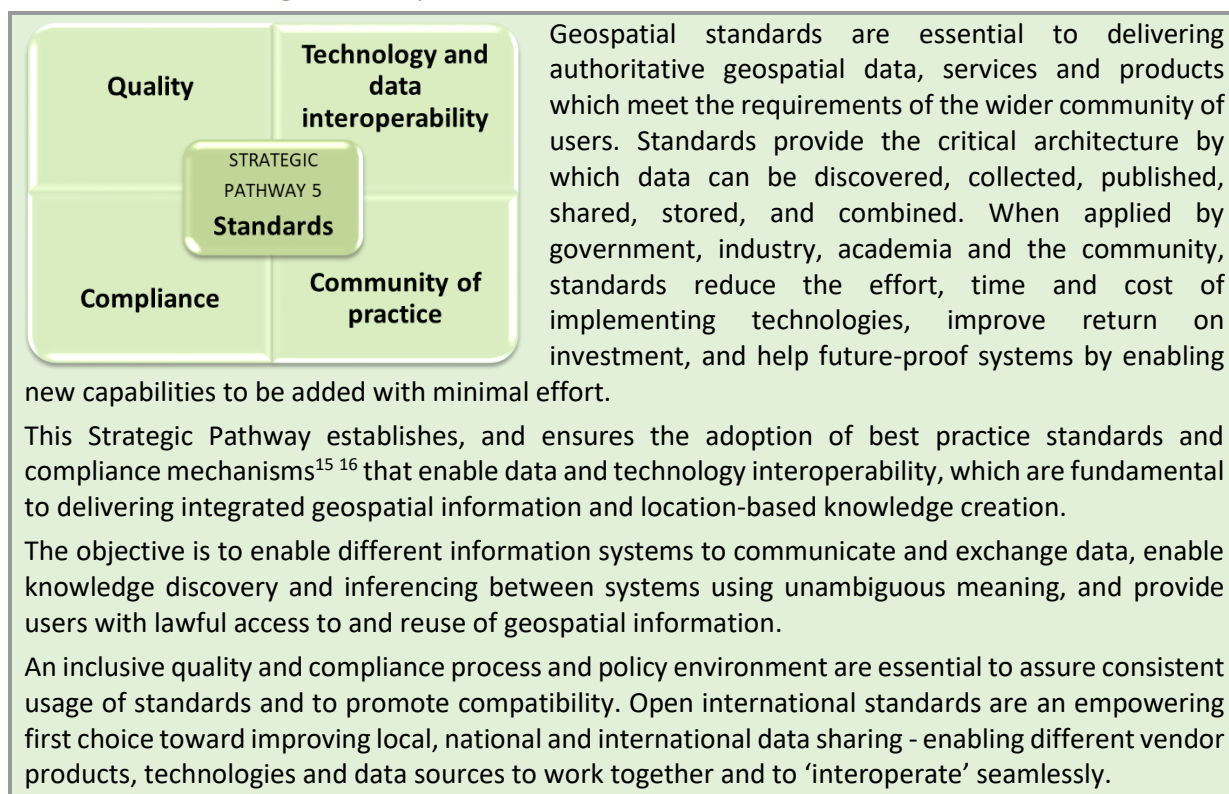
7.3.6.4.3 Custodianship, acquisition and management

Data custodianship mandates responsibilities for the acquisition, management, maintenance and quality of geospatial information. Data custodianship is usually assigned to an organisation, agency or department. It mandates certain rights and responsibilities for the collection and management of geospatial information on behalf of the community. The rights and responsibilities may include the right to set conditions for data release and responsibilities for the acquisition, management, maintenance and quality of the information (GSDI, 2004). This is important, as geospatial information is only useful if the end-user is assured that the data is correct and up-to-date, or that it is the best available at the time. Data custodianship usually includes the need to provide a recognised contact point for the distribution, transfer and sharing of the information. Mandating custodianship is one of the mechanisms used to avoid cross-government duplication in the acquisition and management of information. Data custodians are typically subject-matter experts, the data in their care being recognised as authoritative (GSDI, 2004).

7.3.6.4.4 Data curation and delivery

Data curation and delivery refers to the active and ongoing management of data through its lifecycle of interest and usefulness, including maintaining the value of the data and delivering it to end users in a way that it can be used visualised and used (Horowitz, 2019). The main purpose of data curation is to ensure that data is retrievable for future purposes or reuse. Data curation is usually assigned to a data curator (or integrator) who is responsible for collecting data from many different sources and then aggregating and integrating the data into an information resource, such as a map portal. Data curation has become increasingly important for data analytics, and the private sector has typically engaged in the curation of data to transform independently created government department data sources into unified datasets ready for analysis. Curated geospatial information is therefore often more valuable for decision-making than the individual geospatial datasets (Bishop et al., 2013).

7.3.6.5 Strategic Pathway 5: Standards



Box 7.5: A summary of the four key elements of Strategic Pathway 5: Standards.

7.3.6.5.1 Quality

Quality is a characteristic of comparability that allows for a decision that one thing is better than another. Standards are a measure of quality. Standardisation is the reason for the success of the Internet, the World Wide Web, e-commerce, and the wireless communications revolution (UN-GGIM, 2018c). In the context of geospatial data, the ultimate standard of quality is the degree to which a data set is fit-for-use in a particular application (DiBiase, 2019). By virtue of their nature, international geospatial standards and metadata represent 'quality', facilitating interoperability, standardisation, consistency and more effective implementation of data quality and management. They also streamline data supply chain operations and reduce overheads. Additionally, quality standards are continually evolving, are agile, and are able to consider emerging data technologies such as linked data, the semantic web, and machine readable data. By following nationally and internationally endorsed quality standards, organisations can assure interoperability locally, nationally and internationally.

¹⁵ Developed by the Standards Development Organisations (SDOs) for geospatial information: the Open Geospatial Consortium (OGC); the International Organisation for Standards (ISO) Technical Committee 211 Geographic information/Geomatics; and the International Hydrographic Organisation (IHO).

¹⁶ Building upon the work of the SDOs for geospatial information and their contributions to UN-GGIM: http://ggim.un.org/meetings/GGIM-committee/8th-Session/documents/Standards_Guide_2018.pdf and <http://ggim.un.org/meetings/GGIM-committee/8th-Session/documents/Standards-by-Tier-2018.pdf>

7.3.6.5.2 Technology and data interoperability

Relevant standards and specifications are fundamental to interoperability. Modern ICT capabilities enable organisations to maximise the value of geospatial data and processing by using the expanding framework of the Internet and Web standards to enable interoperability both internally and externally (European Union, 2017; UN-GGIM, 2018b). In the past, such interoperability depended on the tight coupling of systems under centralised control. Today interoperability relies on the wide use of standard interfaces and encodings that enable loose coupling of countless systems that can exchange much more information, at much less cost, than was possible in the past (UN-GGIM, 2018b).

In an effort to promote seamless services and data flows, and to avoid digital fragmentation, the European Union (2017) has developed a new interoperability framework which presents a set of principles and a layered interoperability model. This not only includes technical and semantic interoperability, but also organisational and legal interoperability, both highly relevant in public sector governance and in integrated geospatial information management contexts (European Union, 2017).

Technology and data interoperability enable different systems and diverse data types to work together seamlessly. This in turn, provides the flexibility to rapidly mobilise newer technologies and data sources in the future. Technology standards, such as for Application Programming Interfaces (API), are used to specify how software components interact with each other through standard interfaces to enable different systems and services to work together. When technology standards are implemented independently in products or online services, the resulting components ‘plug-and-play’, working together seamlessly, saving time, effort and cost. Programming to standard interfaces reduces dependency on implementation specifics and makes code more reusable (UN-GGIM, 2018b).

7.3.6.5.3 Community of practice

A ‘community of practice’ is a relatively well-understood term, and is generally referred to as a group of professional people who share the same interests in resolving an issue, improving skills and learning from each other’s experience, particularly within a specific domain or group (Wenger-Trayner, 2015). Within the standards domain, a community of practice is a key element to ensure the implementation of standards, as a wealth of experience and knowledge exists from across the international geospatial community, and from a wide range of thematic topics.

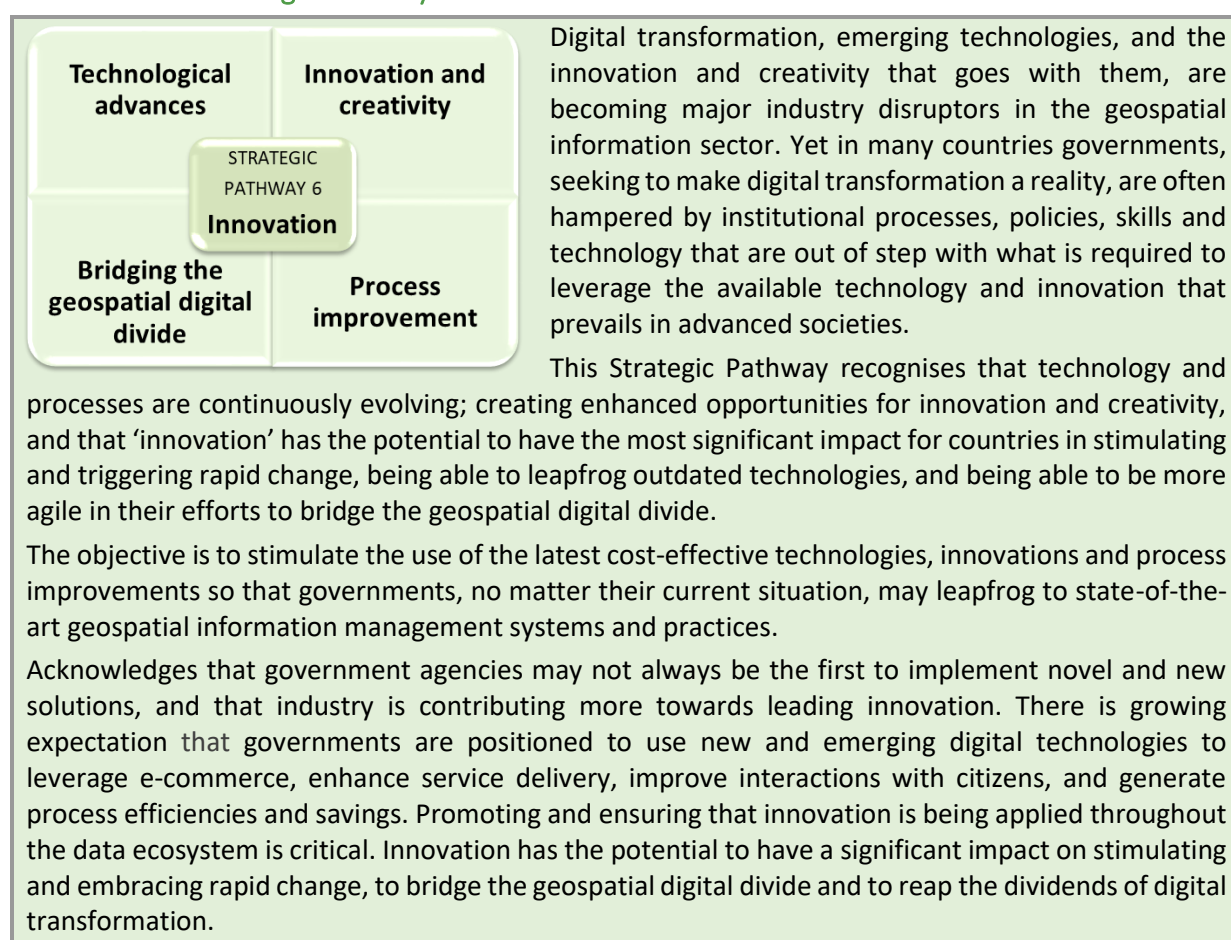
Through partnerships with other countries, the Standards Development Organisations (SDOs) and their expansive public and private sector membership, and with professional associations, countries can identify, assess, and adapt good practices of others, which can greatly reduce the time and effort to improve interoperability for data sharing and application to national issues. While leveraging formal and informal partnerships a community of practice also accelerates the realisation of benefits of standards and interoperability by sharing and leveraging proven, standards-based good practices between what may otherwise be unconnected entities. Through a standards community of practice,

commonality across diverse uses and levels of operation can be realised, helping to promote consistent, sharable standards training and educational programs.

7.3.6.5.4 Compliance

The implementation of standards within the national context is often a combination of bottom-up organisationally driven activities and top-down national incentives in policy and compliance. The successful implementation of geospatial standards requires an efficient compliance model inclusive of relevant stakeholders, and a commitment to assess, establish, and maintain a common standards framework. A system of compliance is used to ensure that organisations are implementing the nationally or internationally endorsed standards that promote data sharing and use, and to verify that technology products and services acquired by government are able to properly implement the required standards. There are several levels of standards compliance that should be considered by countries including regular assessments, government mandates, and testing and certification functions. Standards and conformance provide significant value to government and society, are essential for an expanding national economy, and vital to the global competitiveness of both industry and nations (UN-GGIM, 2018c).

7.3.6.6 Strategic Pathway 6: Innovation



Box 7.6: A summary of the four key elements of Strategic Pathway 6: Innovation.

7.3.6.6.1 Technological advances

As discussed in Chapters 3 and 5, technological advances create new opportunities for economic growth and prosperity. Technologies, both existing and emerging, present the best hope for bridging the geospatial digital divide and achieving broad-based sustainable development outcomes in developing countries (United Nations, 2018c). Technological advances in the geospatial sector are being influenced by a new industrial paradigm – Industry 4.0; where individualised production, horizontal integration in collaborative networks and digital integration of supply chains have emerged (Brettel et al., 2014) to create a new way of producing and distributing information products beyond a single enterprise (Lasi et al., 2014). In addition, general purpose technology (communications, energy and transport) is fundamentally changing the way we manage, power and move economic activity across the value chain (Rifkin, 2014).

Given that geospatial information is utilised in communication technologies to power economic development and environmental sustainability, it is conceivable that geospatial information will be both impacted by, and have an influence on, future economic activity. For example, future autonomous transportation systems will impact data acquisition methods by providing sensors to produce 3-dimensional models of the environment. This information will in turn influence sustainable urban planning and infrastructure development. Emerging technologies include the IoT, automation, sensors, data analytics, machine-learning, deep learning, robotics, Blockchain and quantum computing. These technologies are delivering data on demand, such any IoT enabled device (vehicle sensors, appliances, satellites, phones, etc.). These new avenues for data collection are crucial, as many developing countries do not have good data.

7.3.6.6.2 Innovation and creativity

The 2030 Agenda recognises the importance of promoting and fostering scientific and technological innovation in a number of the SDGs, including to develop policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation to solve sustainable development challenges (United Nations, 2015a). Ultimately, innovation and creativity is about finding new ways to improve the lives of citizens; overcoming old structures and modes of thinking and embracing new technologies and ideas (OECD, 2017a).

While providing great opportunities, the challenges governments face in promoting innovation and creativity can be significant – requiring strategies to overcome bureaucratic barriers, harness the power of citizens', build trusted relationships and enable a culture that supports innovation, growth, productivity and competitiveness (OECD, 2017b). In spite of these challenges, the potential of innovation in government is immense. There are many success stories that demonstrate how government can stimulate innovation and creativity – transforming the way work is done to generate economic growth and societal well-being (OECD, 2017a). Approaches include digital transformation strategies, innovation hubs, research and development, and policy instruments that enable the

management of data as an asset for many uses and users, and opening up access to data to fuel innovation so that societies may reap the benefits.

7.3.6.6.3 Process improvement

Process improvement is the business practice of identifying, analysing and improving existing business processes, to reduce cost, optimise performance, meet best practice standards, respond to policy, or simply improve quality and the user experience for customers and end-users (Radnor, 2010). Process improvement applies to new developments as well as improvements to existing processes and systems. When implementing business process improvement methodologies in the public sector factors such as organisational readiness, success and new developments should be considered. In terms of organisational readiness, this includes elements such as having a process view, developing a culture focused on improvement and, an understanding of the customer and the ‘value’ within the organisation (Radnor, 2010). In terms of new developments it is not always easy nor straightforward to keep track of technology developments. Attending conferences, engaging with colleagues and seeking their advice, are strategies for keeping up to date. These elements of readiness are critical for process improvement, as they provide a basis which new tools and technologies can be applied. Key success factors are strong leadership and visible support from management. Other success factors include an effective communication strategy, appropriate training and development, providing resources and time for the improvements to take place, and using external expertise and support when required (Radnor, 2010).

7.3.6.6.4 Bridging the geospatial digital divide

Chapter 5, specifically the Geospatial Technology Gap (Section 5.4.1.2), details the growing geospatial digital divide in developing countries as a major impediment to innovation and digital transformation. While technologies are evolving at a rapid rate, the commensurate capabilities, digital workforce skills, literacy, resources and opportunities in developing countries are not keeping pace. As a single strategic pathway, innovation has the potential to have the most significant impact for developing countries in stimulating and embracing rapid change, being able to leapfrog outdated technologies, and to bridge the geospatial digital divide, with a combination of technological development, data, supportive policy, financial commitment, stakeholder engagement, partnerships and capacity building.

7.3.6.7 Strategic Pathway 7: Partnerships



As an integrated plan of action, the 2030 Agenda identifies ‘partnerships’, along with people, planet, prosperity and peace, as one of its five defining pillars; and with a specific target to encourage and promote effective public, public-private and civil society partnerships, building on the experience and resourcing strategies of partnerships.

Partnerships, joint ventures, and international cooperation allow for the coordination of policies and strategies, and their implementation. They bring together different strengths and perspectives that stimulate creativity and innovation, often through unique capabilities, and drive achievements towards common goals. Strategic partnerships are collaborative relationships between organisations that have a shared purpose and goals. Partners often join forces to bring diversity, different but complementary skills, knowledge, data and resources to an initiative or development program to improve the effectiveness of geospatial information management that otherwise may not be available, particularly around capacity development and data sharing.

This Strategic Pathway establishes cross-sector and interdisciplinary/transdisciplinary cooperation, coordination and collaboration, with all levels of government, the geospatial industry, academia, private sector and the international community, as an important premise to developing a sustainable Strategic Framework.

The objective is to create and sustain the value of geospatial information through a culture based on inclusion, trusted partnerships and strategic alliances that recognise common needs, aspirations and goals, towards achieving national priorities and outcomes.

Box 7.7: A summary of the four key elements of Strategic Pathway 7: Partnerships.

7.3.6.7.1 Cross-sector and interdisciplinary cooperation

The implementation of the Strategic Framework will require actors from multiple disciplines and sectors cooperatively working together to examine and redefine problems from various perspectives in search of solutions and outcomes. This cooperation can take on many forms, from simple networking where information is shared for mutual benefit, to more structured coordination and collaboration where organisations may have to alter their data management processes and protocols and agree to share data, resources and systems for a common purpose. An organisation may establish a cross-sector interdisciplinary team of professionals to work on a complex project where multiple skillsets or areas of expertise are required in order to succeed (Soininen, 2014). For example, a flood risk management system will require fundamental geospatial data and expertise, as well as complex hydrological models and hydrologists, to work together toward a common goal to manage flood hazards and respond to disaster events. This includes collaborating with disaster managers, governments, legislators and policy makers in aspects of regulatory frameworks, communication experts, and delivery systems technicians to name a few. In addressing issues related to mandates and authoritative data, this collaboration between governments, legislators and policy makers is crucial.

Another example of cooperation may be where two or more agencies decide to co-manage a geospatial data theme. This type of cooperation requires a significant level of trust between partners, as well as an ability for the agencies to share roles and responsibilities in all aspects of planning, governance, implementation, and evaluation and review, to create a better or more seamless geospatial information management system.

7.3.6.7.2 Community participation

Community participation in this strategic pathway refers to the involvement of individuals and community groups in geospatial information initiatives or projects to solve their own problems. It recognises that community engagement is an important element of partnerships, to ensure inclusiveness and ownership; and that in many developing countries, the community can influence decision-makers and politicians. The importance and value of community participation has increased significantly through the rapid expansion of the sharing economy. Acquiring, providing and sharing access to geospatial information through community-based on-line platforms is realising new economic model(s) – one of co-creation and/or co-production, and with collaborative consumption. Businesses are developing goods and services that rely on regularly contributed and updated geographic information. Ride-sharing and renting out an unused item such as bicycles, cars, rooms or houses are examples of how the community are actively participating in this collaborative consumption model by providing and using value-added geospatial information. Community participation is especially important in emergency services programs where people contribute local knowledge about their location and surroundings to improve emergency preparedness, mitigation, response and recovery. Government transparency is important to people and they want to be able to participate in major policy-setting and decision-making that are important to them. Being able to contribute geographic and demographic information through knowledge-sharing systems means that they have a greater say in how they live their lives, and in ways that matter (Quill, 2018).

7.3.6.7.3 Industry partnerships and joint ventures

Strategic partnerships and joint ventures with the private sector, the broader geospatial industry and related companies, and educational and research institutions, facilitate and support positive collaborative outcomes for government and stakeholders through local, national and international collaborative activities or ventures. These also ultimately provide positive benefits to the community. Partnerships are able to bring together organisations with differing, but often complementary, missions, knowledge, approaches, resources, business culture, expertise and experiences, and even values, to find an equitable approach that delivers geospatial information benefits and value for all. Evidence is unfolding that incremental benefits accrue by developing a geospatial information management ecosystem that also includes academic engagement, and peer-level private sector engagement (Longmore, 2018).

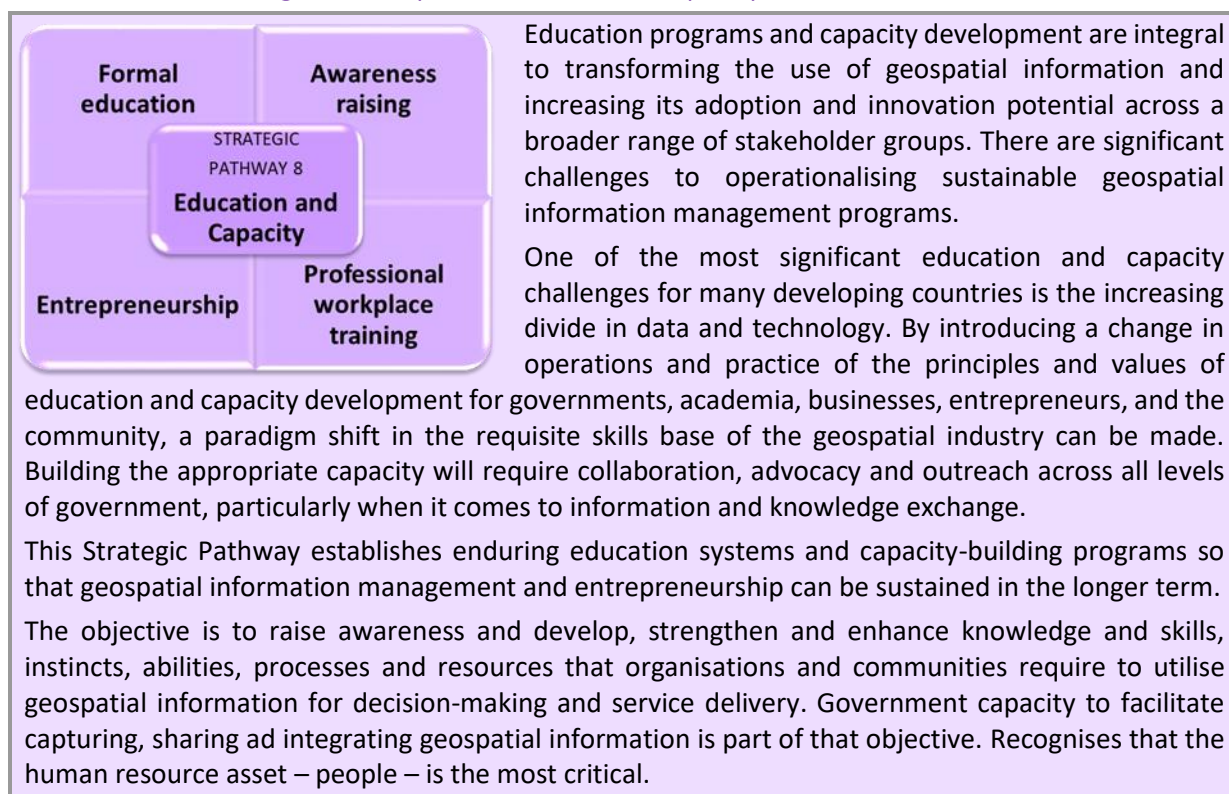
Benefits include greater access to knowledge, mitigating risk, and reducing potential mistakes through greater understanding, being able to draw from a wider pool of technical expertise, cost sharing, increased innovation potential, and the ability to more readily overcome challenges. In cooperating with educational and research institutions, there is the ability to benefit from the scientific, technical, research and learning capacity available, and the ability to discover and access specialist knowledge resources and capital. Similarly, public-private and civil society partnerships can address user interest, needs and demands, and considerably enhance technological and market-driven innovation. Further, public-private partnerships can be seen as an activity or project, or a form of service delivery mechanism. Such partnerships can also be a stated intent in a government policy statement, and generally involve the sharing of risk, as a way of financing and joint development (Andrews and Entwistle, 2015).

7.3.6.7.4 International collaboration

International collaboration (including regional and sub-regional collaboration) refers to the interaction between organisations representing various nations in the pursuit of common goals or interests, and is crucially important to support the implementation of the SDGs. International and regional collaboration enables countries to develop partnerships leveraging their respective integrated geospatial information capabilities to accomplish transboundary, regional and/or global objectives and outcomes. The collaboration can include partnerships with international aid agencies, philanthropic foundations and official development agencies. Typically, this cooperation involves technical support, knowledge exchange and funding, as well as affording access to regional and global networks and, at times, to strategic levels of government and politics.

Regional and international partnerships and cooperation are needed in many instances to afford national geospatial information entities the opportunities, capacities and capabilities to leapfrog into the digital economy and modern geospatial information arena. These are enabled and supported by advances in communications technology and related infrastructures, but the primary driver and benefit is often to gain access to complementary knowledge, expertise, experience, technology and financial resources. International collaborative partnerships and cooperation can build consensus and support transboundary solutions for the mutual benefits of all citizens (OECD, 2011).

7.3.6.8 Strategic Pathway 8: Education and Capacity



Box 7.8: A summary of the four key elements of Strategic Pathway 8: Education and Capacity.

7.3.6.8.1 Formal education

Chapter 5 (Section 5.3) determined that a key element of the digital divide, the Digital Adoption Gap, is also a human skills and knowledge transfer divide – stemming from a lack of basic education, training and awareness. Andreasson (2015) noted that, like social divides, education and literacy rates are fundamental challenges to bridge digital divides. Formal education offers a sound foundation in topics important to understanding concepts of geography and geospatial information management that contribute to a high return on investment in education via skills and knowledge taught, and research provided, in a traditional formal educational setting. Formal education programs are delivered by trained teachers in a systematic intentional way within a school, higher education institution or university. Investing in technical and tertiary education has significant impact on national capacities. Evidence indicates that countries, which invest in their post-secondary education systems, have developed capacities that have borne fruit over a much longer period of time (UNDP, 2009).

In many countries, without the prerequisite skills, one cannot do their work. Acquiring the foundational education, training and knowledge to then be equipped with the skills to be applied to and deliver capacity and capability development is essential. An impediment for some developing countries is that professionals trained abroad are not able to utilise or transfer the knowledge they have gained to others on their return. This is often because they do not have access to the same technology and

resources they had while studying overseas, or they are simply not in positions to influence capacity and capability development, in an organisation.

7.3.6.8.2 Awareness raising

Awareness raising is achieved formally through education and training programs and informally through observation and hand-on experiences. Awareness raising provides a means to promote the value and benefits of geospatial information via educational techniques including contact courses, online courses, and outreach programs involving different interest groups, individuals and communities. This is vital to not only sustain, but increase the number of primary and secondary school children with knowledge and skills in geography, and graduating professionals in geospatial information and related sciences. Having these skills permeating throughout government, industry and the private sector leads to the growth of capabilities and innovative solutions that contribute to economic growth and national development. Leadership is a key ingredient for effective awareness raising. It is through leadership, including the teaching faculty, that people (including key decision-makers) become familiar with the value and benefits of geospatial information; and are influenced, inspired and motivated to respond to the changes needed to strengthen capability (UN-GGIM, 2015b).

7.3.6.8.3 Professional workplace training

While foundation skills and knowledge are traditionally taught in a formal educational setting, they can be significantly developed and refined with professional workplace training, research and ongoing lifelong learning. Organisations now recognise that modern workforce competences are essential if they are to take advantage of the latest technologies to stimulate innovation potential, and to enable work to be accomplished far more quickly and sophisticatedly than with traditional methods. Professional workplace training can be achieved through on-the-job training, study tours, research and fellowship programs, and conducted both internally and externally. This training offers intensive, up skilling and hands-on experience in systems where new methods and practical experiences have significant benefits to a geospatial organisation, oftentimes in response to an inventory of knowledge, skillsets and resources, as well as the opportunity to develop professional networks and mentorship. Lifelong learning refers to the ‘ongoing, voluntary, and self-motivated’ pursuit of knowledge for either personal or professional reasons. Therefore, it not only enhances social inclusion, citizenship, and personal development, but also self-sustainability, as well as competitiveness and employability (European Commission, 2007).

With external workplace training programs, there is often more opportunity to observe and gain hands-on experience in state-of-the-art systems, such as through international partners or donor fellowship programs that have effective educational systems and policies in place. Being able to observe and apply new methods and gain practical experiences has significant benefits, not just because of the new knowledge and skills earned, but also because of the opportunity to develop professional networks and mentorship. Professional workplace training is not only suited to geospatial professionals but also

allied professions that use geospatial information in their work, such as planners, emergency responders, construction engineers, agriculturists, statistics analysts, and forest and fisheries managers, etc. Professional development activities are also an effective mechanism for attracting and keeping employees engaged, which is crucial in countries that suffer from high staff turnover and knowledge and skills drain.

7.3.6.8.4 Entrepreneurship

While digital transformation, technologies, and the innovation and creativity that goes with them, are becoming major industry disruptors in the geospatial information sector, it is through entrepreneurship that ideas and creativity are realised. Entrepreneurs design, launch and run new business ventures and are critical to vibrant and growing economies. Governments can support and stimulate entrepreneurship through innovation programs that grow the capabilities of the business sector to develop products and services that are underpinned by geospatial information. This support is important. As emerging start-ups, entrepreneurs are often exposed to risks when bringing new ideas to market; and yet, they are very quickly able to create business opportunities and advance capabilities, while also solving societal problems. National geospatial innovation hubs and programs¹⁷ have been established to foster entrepreneurship through capacity development, public private partnerships, learning programs, and mentoring opportunities. These programs are targeted at both early stage start-up companies and seasoned corporations that are looking to adopt geospatial technologies, processes, specifications and data to solve problems and build new applications. They create solutions and jobs, support national prosperity and bring together multiple disciplines from the private sector, academia and government agencies to drive geospatial innovation and data use (Desta, 2018; Rocha et al, 2019).

¹⁷ National government examples include Geovation in the United Kingdom: <https://geovation.uk/>; GeoHive in Ireland: <https://geohive.ie/index.html>; and GeoWorks in Singapore: <https://geoworks.sg/>.

7.3.6.9 Strategic Pathway 9: Communication and Engagement



Box 7.9: A summary of the four key elements of Strategic Pathway 9: Communication and Engagement.

7.3.6.9.1 Stakeholder and user engagement

Having stakeholders that are engaged, committed and have bought in will be critical to implementing the Strategic Framework. Stakeholder and user engagement identifies and develops relationships and alliances with users, partners, advocates and third parties. Given the underlying nature of geospatial information management, stakeholder interests, needs and motivations will be diverse, priorities will need to be set, and expectations managed as they evolve over time. Stakeholders and users will likely come from differing professional and user domains, bringing a range of perspectives, requirements and expertise. These stakeholders may include politicians and policy-makers, government organisations and their employees, local government, municipal or provincial agencies, development organisations, philanthropic entities, geospatial information users (both professional and general), scientific institutions, universities and research institutions, private sector suppliers (data, technology and services), private sector users, non-government organisations and volunteer groups (as supplier, user and partner), consumers, and citizens (often the beneficiaries).

It will be important to identify these stakeholders and users, including emerging users, early and analyse their level of interest, expectations, importance and influence. Stakeholders may have a role in collecting, managing, disseminating and sharing geospatial information, and/or using it for a range of services and applications. Their views, levels of understanding, and levels of engagement will

differ – ranging from technical, governance, policy and legal perspectives, to financial, business, educational and employment insights. Not all stakeholders and users may be identified or known early in the process, while other potential stakeholders will emerge immediately (Bryson and Patton, 2010).

7.3.6.9.2 Strategic messaging and engagement

Strategic messaging and engagement is a key element to the early and smooth implementation of the Strategic Framework. Engagement strategies are targeted to being responsive to the current and future needs of stakeholders and users, and about providing opportunities for stakeholders to have a share in shaping national geospatial information management and its priorities. Messaging and engagement seeks to develop the narrative of clear, succinct, compelling and strategic messages to all constituents and audiences to stimulate initial understanding and buy-in, and to retain support during implementation. Importantly, engagement strategies are the mechanisms to ensure that any geospatial information policy and strategy is developed in a consultative manner, but may require proactive and ongoing communication over extended periods of time.

The strategic messaging will feed into support for, and development of, national policies and strategies. Ideally, a national geospatial branding should be developed. A brand will strategically support messaging and engagement, increasing the likelihood of others to see what nationally integrated geospatial information management is about, and to be associated with a ‘winner’. Coupled with strategic engagement, approaches will enable stakeholders, users and the general community to participate meaningfully in the processes, decisions and actions that will strengthen geospatial information management and its utility. In using messaging and engagement strategies, countries can meaningfully involve individuals, organisations and other groups in policy and program development, as well as creating awareness and generating momentum, embed communications across the implementation process, and focus on key concepts that compel the reasons to change. Messages must be strategic, appropriate to the occasion and circumstances, honest and unembellished, that engender trust, and that promote acceptance and buy-in (Bryson and Patton, 2010).

7.3.6.9.3 Communication strategy, plans and methods

A communication strategy, plans and methods guides an entire program and sets the tone and directions so that all communication activities, products and materials work together to achieve the desired objectives and related change. A communication strategy also enables stakeholders to provide inputs and agree upon the best way forward so that targeted messages, content and actions are unified as they identify, engage and communicate with stakeholders and users. (Compass, 2020). They reflect the understanding of prevailing circumstances, stakeholder needs, perceptions and interests, including to sustain communication channels and information flows while growing the adoption of the Strategic Framework. Planning and execution is critical to ensure the impact and influence of communication strategies and plans, and takes into consideration that potential stakeholders will only become active participants if they see benefits for their organisation or groups and customers. A committed approach

will lead to better outcomes for the individuals, groups and organisations that are affected by, or can influence, government's geospatial information management activities.

Much of the focus of this strategic pathway will be on cross-government engagement and external engagement. However, effective communication strategies, plans and methods must also incorporate the need to engage and communicate with those working in the organisations already delivering surveying, mapping, valuation, building cost, and geospatially referenced data. For them, the potential change could be perceived as a threat or an opportunity; it needs to be rightly seen as opportunity through effective internal communication. Sharing information within an organisation helps to assure success of the communication strategies and plan. Without staff understanding, buy-in and support, the likelihood of a successful communication campaign is diminished. Frequently sharing new information, seeking staff ideas, inputs and feedback, and responding to staff questions are examples of successful internal communications. Internal communication team(s) work in partnership with leaders to identify and engage staff within their organisation.

7.3.6.9.4 Monitoring and evaluation

A monitoring and evaluation process sets the performance measures to track and assess the effectiveness of the strategic messaging and engagement, communication strategies, plans and methods, including activities and procedures to identify, engage and sustain the stakeholder and user community. This process aims to evaluate whether the planning and preparation aspects have been effective for identifying and communicating with stakeholders, and whether the engagement activities and procedures have achieved the intended outcomes, including potentially part of the policy cycle within government. The monitoring and evaluation process is typically incorporated into normal operations and, at times, as a feedback mechanism. It provides the opportunity to reflect and re-think communication and engagement practices as the Strategic Framework is implemented. These efforts address the questions 'how well did we do', 'how well have we communicated', and 'have we been effective or impactful', in assessing the effectiveness of the communication strategies and plans. Effective monitoring and evaluation allows continual improvement including recalibration of communication and engagement strategies and efforts. It ensures strategic stakeholder and user engagement, effective messaging, and where the communication strategy, plans and methods are keeping pace with change, and delivering strategic messages that continually contribute to an enabling environment for nationally integrated geospatial information management (Wholey, 2010).

7.3.7 Benefits

BENEFITS (SOCIETAL)	Knowledge Decisions Action Development Society Economy Environment Government Users Citizens Access Technology Applications Value Engagement
BENEFITS (THEMATIC)	Water Energy Tourism Health Education Infrastructure Security Population Defence Industry Transport Disasters Urbanisation Food Supply Planning

Geospatial information is a form of infrastructure for decision-making that supports many societal activities, including by individuals (Pearlman et al., 2014). Bernknopf and Shapiro (2015) argue that the cost of supplying geospatial information is greatest to the first user, and that the cost of disseminating information to additional users is relatively small – referred to as ‘jointness of supply’. This infers a value of the information (VOI), or benefits of the information. Most VOI analyses consider the ‘tangible’ costs of geospatial data collection and the potential cost savings to society accruing from the presence (rather than absence) of the subsequent geospatial information. However, there are also ‘intangible’ societal benefits that can result from making more informed decisions from the data, especially if the said data does not exclude anyone from the benefits of its use (Bernknopf and Shapiro, 2015).

Therefore, the ultimate benefits, including the considerable economic benefits, of integrating and strengthening national geospatial information management is that it is a strategic enabler for all levels of government and the broader community. It improves planning for economic growth and delivery of better services. It supports the delivery of the SDGs, such as poverty alleviation, socially inclusive development, protection of the environment, disaster response times, regional cooperation and transparency in governance.

As described in Section 7.3.6.3.4, understanding and realising the benefits of the Strategic Framework, including the outcomes and value proposition, is one of its greatest influencing factors. Figure 7.2 illustrates the broad societal and thematic benefits of the Strategic Framework, while Figure 7.3 repeats these for the nine strategic pathways – surrounded by the societal benefits that are able to be realised when the pathways are implemented together. Not intended to be exhaustive, but indicative, these societal benefits include government, the citizen, users and access, in the three areas of sustainable development – social, economic and environmental, and leveraging the value of data, technology and applications to derive engagement outcomes that include knowledge, decisions, action, and development – and at the end of the day, national prosperity and deliver the vision and mission of the Strategic Framework.

The thematic benefits, again intended to be indicative, include many of the thematic application areas for which geospatial information provides the underpinning location infrastructure needs to support strategic priorities and outcomes, and through these, sustainable development. A key

consideration in acknowledging these societal and thematic benefits, is that geospatial information, by virtue, is not limited to one particular industry or sector, is cross cutting among multiple industries and sectors, and forms the universal ‘location’ enabler for many industries and sectors.

7.4 Adoption of the Strategic Framework by UN-GGIM

Before concluding this Chapter and presenting the case studies of Africa and Ethiopia in Chapter 8, providing the consultative process to gather the data, validate, and bring the components of the Framework together, it is important to pause and provide an important and influential dimension to this research that was not originally foreseen. This was a consultative validation and feedback process that evolved at the global level.

With reference to the research design and methodology (Chapter 4), Creswell (2002) recommends that the topic of the research should connect with the career objectives of the researcher, so expertise for this career can be developed. The researcher has, since early 2012, provided strategic policy advice and leadership in guiding the development, coordination and implementation of the substantive content and program of work of UN-GGIM within the United Nations. Therefore, when embarking on this research, part of the approach was for the Strategic Framework to be recognised by countries and eventually be adopted by the United Nations, and subsequently implemented through the intergovernmental process of UN-GGIM. Such an acknowledgement would not only validate the importance and need of the Framework, but ensure that the Framework is suitable for implementation by at least the world’s developing countries, if not all countries of the world.

That recognition and adoption was recognised much sooner than anticipated. As mentioned briefly in Section 7.3, through the leadership role in the United Nations, the researcher was provided with a unique opportunity to implement and lead a collaborative partnership between the United Nations and World Bank to progress an overarching geospatial framework to assist developing countries to bridge the geospatial digital divide, and based directly upon this research. The timing and setting for developing this Strategic Framework, combined with persistence and hard work by the researcher, realised this aspiration in August 2018.

Following a very condensed preparation period and global consultation with Member States of the United Nations, the Strategic Framework, as presented in this Chapter, was submitted to and adopted by UN-GGIM at its Eighth Session in New York in August 2018 as the *Integrated Geospatial Information Framework [IGIF] Part 1: Overarching Strategic Framework* (UN-GGIM, 2018d). Specifically, UN-GGIM adopted the IGIF, as “*the overarching strategic framework, as a forward-looking document developed to provide overarching strategic messages in the context of an expansive, integrated national framework, focusing on the policy, perspectives and key elements of geospatial information, and in this regard supported the preparation of an illustrative summary as a high level reference document aimed at enhancing geospatial awareness for policymakers and decision makers*”

(United Nations, 2018b, Decision 8/113). The IGIF will eventually comprise three separate, but connected, documents. As indicated in Figure 7.4, Part 1 is the Overarching Strategic Framework; Part 2 is an Implementation Guide; and Part 3 is a Country-level Action Plan. The three parts comprise a comprehensive IGIF that serve a country's needs in addressing economic, social and environmental factors, which depend on geospatial information in a continually changing world. At this time, it is only the Overarching Strategic Framework that is complete, but the Implementation Guide and Country-level Action Plans are now being developed by UN-GGIM, guided by the researcher.

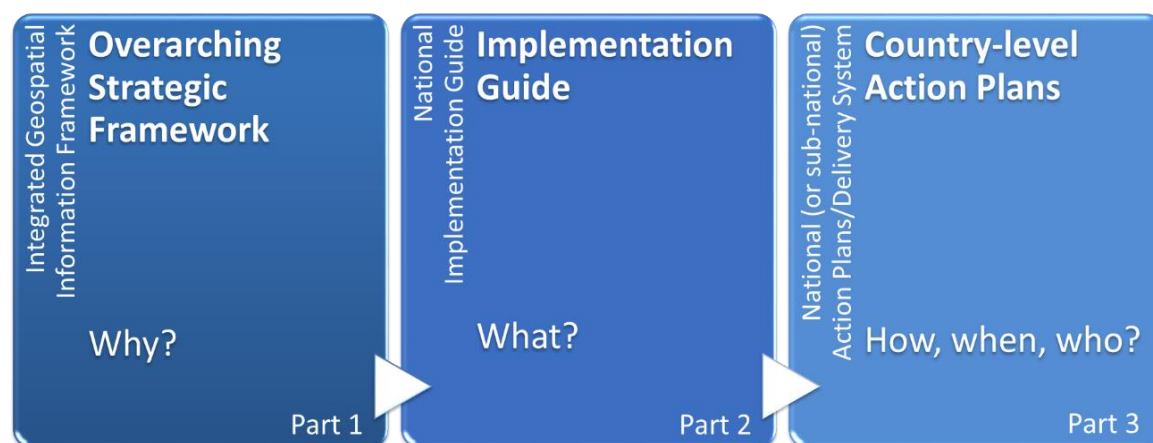


Figure 7.4: The 3 component documents of the Integrated Geospatial Information Framework (UN-GGIM, 2018d).

The IGIF Overarching Strategic Framework, as adopted by UN-GGIM, is presented in Figure 7.5. While visualised and presented slightly differently, and apart from subtle variations in the strategic pathways, key elements, and benefits, it is a direct adaptation of the Strategic Framework as presented in Figure 7.2. The essence and intent of the Vision, Mission, Strategic Drivers, 7 Principles, 8 Goals, 9 Strategic Pathways, and Benefits remain consistent. The three-by-three matrix of the nine strategic pathways adopted by UN-GGIM is provided in Figure 7.6. Again, this represents a direct adaptation from Figure 7.3. The subtle variations relate to the fact that the Strategic Framework pathways (Figure 7.3) have been structured vertically through the three levels of enabling NSDI capability, while the IGIF has not (Figure 7.6). The Level 2 (Policy and Legal, Standards, and Education and Capacity) strategic pathways are where the difference occurs.

For the IGIF strategic pathway diagram (Figure 7.6) an improvement was the jigsaw-style graphic. This was chosen to illustrate that the pathways are interconnected with one another and across the entire three-by-three pattern of strategic pathways. The variable shape also implies that the information offered about the strategic pathway is comprehensive but not exhaustive – and no two pathways are the same. It also reinforces the mantra of this research, that when the pieces are all joined together and united as one, the Framework is connected, integrated and able to be fully implemented.

VISION								
The efficient use of geospatial information by all countries to effectively measure, monitor and achieve sustainable social, economic and environmental development – leaving no one behind								
MISSION								
To promote and support innovation and provide the leadership, coordination and standards necessary to deliver integrated geospatial information that can be leveraged to find sustainable solutions for social, economic and environmental development.								
STRATEGIC DRIVERS								
National Development Agenda • National Strategic Priorities • National Transformation Programme • Community Expectations • Multilateral trade agreements • Transforming our World: 2030 Agenda for Sustainable Development • New Urban Agenda • Sendai Framework for Disaster Risk Reduction 2015–2030 • Addis Ababa Action Agenda • Small Island Developing States Accelerated Modalities of Action (SAMOA Pathway) • United Nations Framework Convention on Climate Change (Paris Agreement) • United Nations Ocean Conference: Call for Action								
UNDERPINNING PRINCIPLES								
Strategic Enablement	Transparent and Accountable	Reliable, Accessible and Easily Used	Collaboration and Cooperation	Integrative Solution	Sustainable and Valued	Leadership and Commitment		
GOALS								
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	International Cooperation and Partnerships Leveraged		Enhanced National Engagement and Communication		Enriched Societal Value and Benefits			
STRATEGIC PATHWAYS								
Governance and Institutions	Legal and Policy	Financial	Data	Innovation	Standards	Partnerships	Capacity and Education	Communication and Engagement
Governance model Institutional structures Leadership Value proposition	Legislation Implementation and accountability Norms, policies and guides Data protection and licensing	Business model Investment Partnerships and opportunities Benefits realization	Fundamental data themes Data supply chain interlinkages Custodianship, acquisition and management Data curation and delivery	Technological advances Promoting innovation and creativity Process improvement Bridging the digital divide	Legal interoperability Semantic interoperability Data interoperability Technical interoperability	Cross-sector and interdisciplinary cooperation Community participation Industry partnerships and joint ventures International collaboration	Awareness raising Entrepreneurship Formal education Professional workplace training	Stakeholder identification Planning and execution Integrated engagement strategies Monitoring and evaluation
Knowledge Decisions Development Society Economy Environment Users Citizens Access Technology Applications Value								

Figure 7.5: The IGIF Overarching Strategic Framework (UN-GGIM, 2018d).

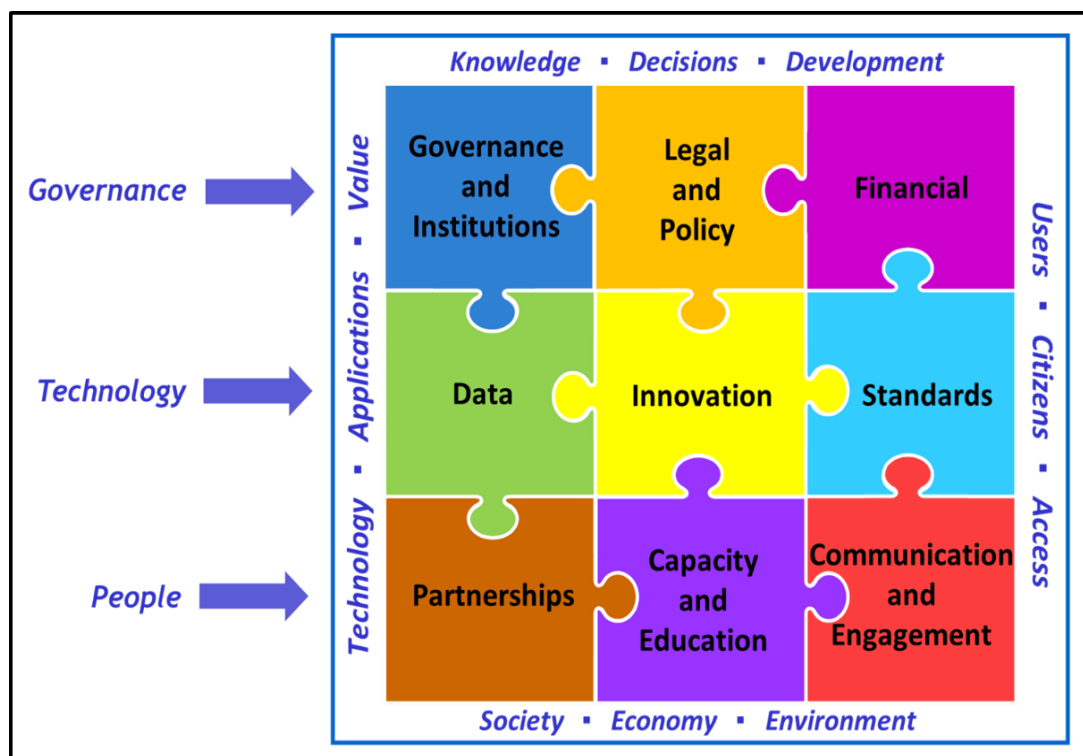


Figure 7.6: The strategic pathways of the IGIF Overarching Strategic Framework (UN-GGIM, 2018d).

In its adoption in August 2018, the additional detail and elaboration of the strategic pathways and their key elements of the IGIF (as described in Section 7.3.6 above) had not been initiated. These have since been further developed and completed in consultation with countries by the researcher; hence the variations in the strategic pathways and key elements in Figures 7.2 and 7.5.

The adoption of the IGIF by UN-GGIM in August 2018 has had a major influence on how the researcher approached the case studies in Chapter 8. The case studies are the means to validate, test and apply the Strategic Framework to demonstrate that it can be tailored to countries for their own national circumstances and needs. However, the process of formulating, seeking global consensus, and adopting the IGIF by UN-GGIM not only recognised the development and urgent need of the Strategic Framework in its entirety, but it also enabled further consultations and refinements to strengthen the Framework with a broader perspective, beyond just the needs for Africa – and under the new and growing branding of the IGIF. In order to avoid confusion between the overlap in the development of the Strategic Framework and its adoption as the IGIF, for the remainder of this dissertation, particularly the case studies in Chapter 8, the Strategic Framework will be characterised as the IGIF.

Figure 7.7 contextualises this overlap and transition, from the first data gathering consultation workshop with African countries in April 2018 in Addis Ababa, Ethiopia, to the final consultations and workshops in February 2020. During this period, sixteen consultations and workshops were convened. The four Africa case study consultations (detailed in Chapter 8) are shown in red, while a series of nine further ‘validation’ regional workshops convened by the researcher are shown in green. The three

additional consultations shown in magenta could not be convened by the researcher due to their conflict with other workshops that were being convened simultaneously. The write-shop meeting organised by the researcher with six global experts (Section 7.3.6) is shown in orange, while the annual intergovernmental sessions of UN-GGIM are highlighted in blue. It was at the Eighth Session of UN-GGIM that the IGIF was adopted.

It should be noted that from April 2018 to November 2019, the researcher convened and directly facilitated eleven expert workshops and consultative meetings with a broad range of stakeholders from countries, academia, industry and the private sector, and from all geographic regions. In this process, more than 120 individual countries were formally represented and participated, many several times. Inclusive of the three additional workshops that the researcher did not facilitate, Figure 7.8 maps a total of 133 countries (in blue) whom participated in the process of developing the Framework. The deliberate effort to engage with the Latin-America, Africa, and Asia-Pacific regions – representing many of the world’s developing countries – is highlighted in red.

These expert consultations have yielded an enormous wealth of diverse data, information and guidance that has greatly contributed to, informed, and enhanced the purpose, structure and substance of the IGIF, as well as the components of the Implementation Guide and Country-level Action Plans. Of particular note were the three-day plus regional workshops for developing countries convened in Chile, China, Ethiopia (twice), Malaysia and Rwanda.

As presented in Figure 7.4 and mentioned earlier, the IGIF Implementation Guide is now being developed by UN-GGIM, and led by the researcher. Although not yet complete, the Implementation Guide will be the means to provide the detailed guidance and options for actions to be considered and undertaken in implementing the IGIF. It will be a reference resource that defines, describes, and offers helpful guidance and options on actions to be taken for each of the nine strategic pathways. Recognising that every country is at different levels of maturity in their geospatial development journey, the Implementation Guide is not intended to be prescriptive, but rather to provide guidance. The guidance is comprehensive, but still general enough to be applicable to all countries, and sufficiently flexible so that each country can develop their own plan of actions to meet their national priorities and circumstances. Each strategic pathway is comprised of a dedicated chapter within the Guide, and will have a standard structure and form for consistency and clarity.

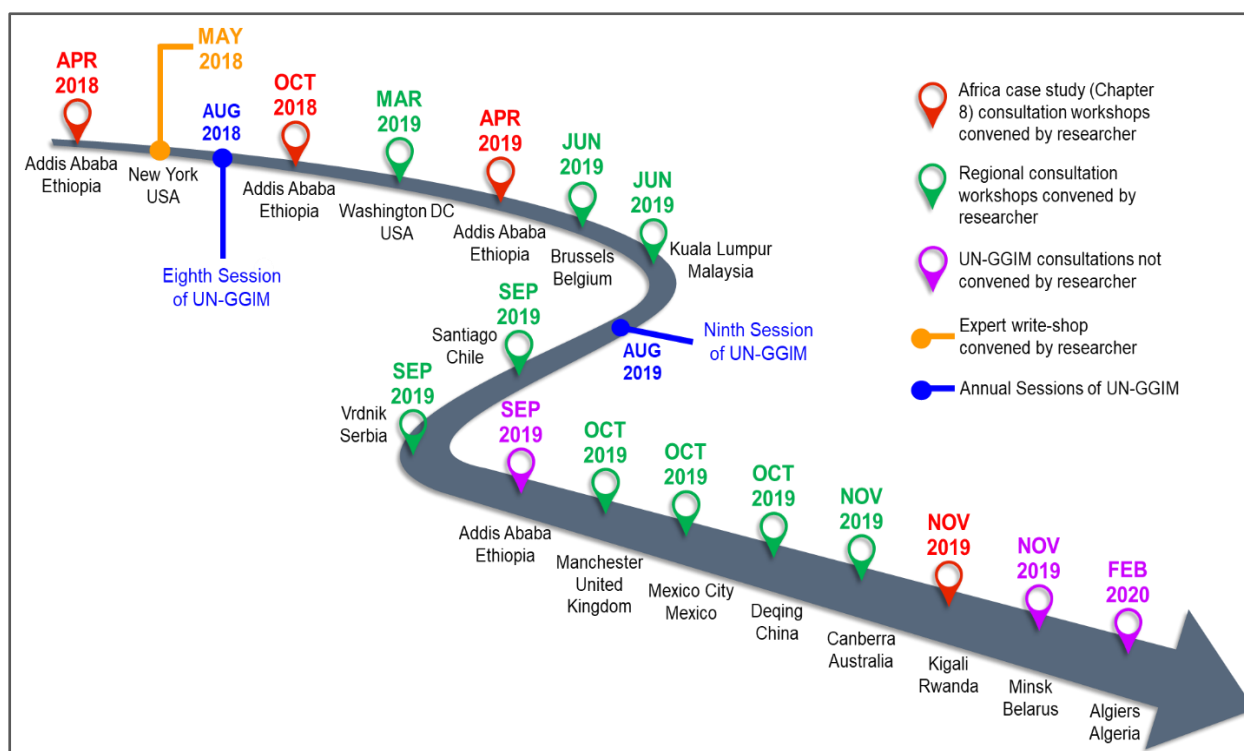


Figure 7.7: Consultations and workshops convened by the researcher (red and green) in the data gathering and development of the Strategic Framework and IGIF, including for the Africa case study (red).

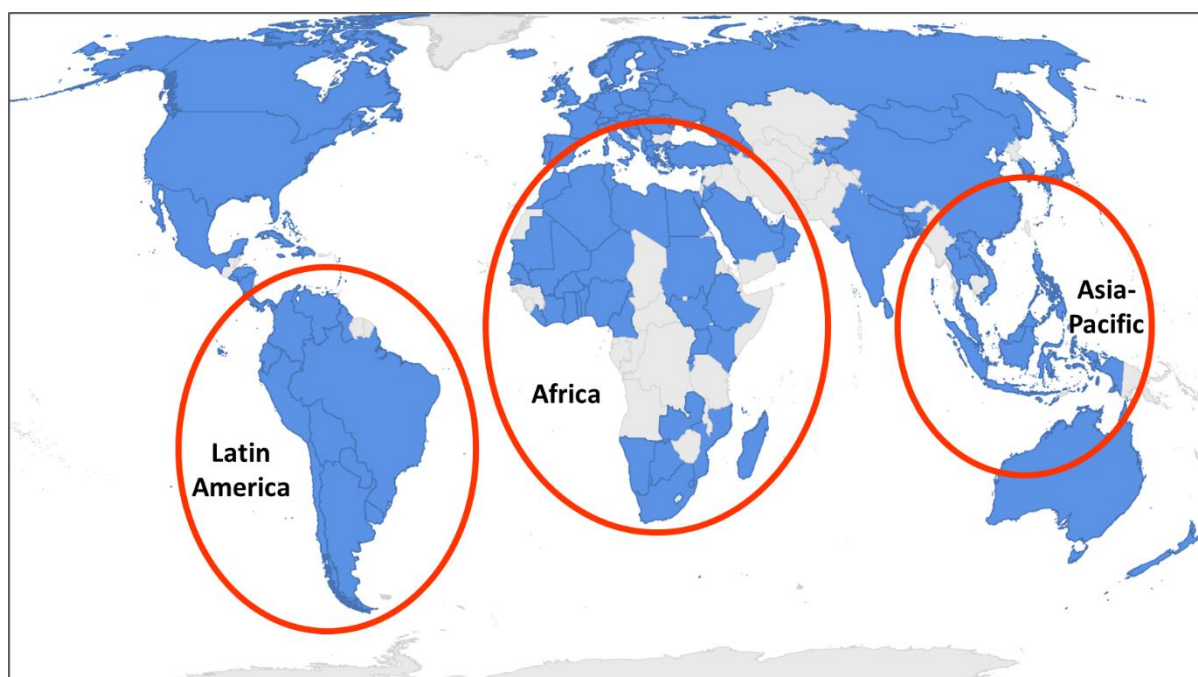


Figure 7.8: From April 2018 – November 2019, 16 consultation workshops directly engaged 133 countries (blue), many representing the world's developing countries from the Latin-America, Africa, and Asia-Pacific regions (red circles).

7.5 Chapter Summary

This Chapter introduced and described a new National Strategic Geospatial Information Framework for the global geospatial community and for all countries – developed and developing. Designed and structured to be inclusive, universal and transformational, the Strategic Framework presents a forward-looking approach that will assist in addressing the understanding and knowledge gaps in sustainable development. It creates an enabling environment where national governments can coordinate, develop, strengthen and promote the efficient and effective use and sharing of geospatial information for policy formulation and evaluation, decision-making and innovation – and in turn bridge the geospatial digital divide. With strong ownership and leadership by government and other national stakeholders, the Strategic Framework establishes the conditions and processes that enable the sustainability of the data ecosystem, regardless of the various national and sub-national administrative settings and organisational environments that may exist.

In recognition of its direct relevance and applicability for all countries, the Strategic Framework quickly evolved as the basis for the United Nations Integrated Geospatial Information Framework (IGIF), a Framework to strengthen geospatial information management, assist countries in bridging the geospatial digital divide, secure socio-economic prosperity, and leave no one behind (UN-GGIM, 2018d).

The next Chapter describes how the Strategic Framework, presented as the IGIF, is able to be synthesised, implemented and prototyped via a two-dimensional case study – regionally within the continent of Africa, and nationally within the country of Ethiopia. The case study will demonstrate how geospatial information can be integrated into national sustainable development policies and strategies. It will also consider the role of the NSDI, as the national geospatial information system of the sustainable development data flow framework, as a means to provide reliable fundamental geospatial data, and to provide both the enabling platform and connection point to other national information systems, and to the SDGs.

Chapter 8 – Implementation Case Study

8.1 Introduction

The three previous research Chapters considered and addressed the significant dependencies on geospatial information and emerging technologies, bridging the geospatial digital divide (especially in the African context), the need for an integrated geospatial information systems ‘data flow’ framework, and culminating with the development of a National Strategic Geospatial Information Framework in Chapter 7. The Strategic Framework was subsequently adopted by UN-GGIM as the IGIF in August 2018, with naming and refinement now referred to the IGIF in this Chapter. Designed for the global geospatial community, for all countries, the IGIF provides a means to bridge the geospatial digital divide, to provide a basis and guide for countries towards developing and strengthening arrangements in national geospatial information management, and particularly to meet and overcome complex sustainable development challenges for developing countries.

This Chapter now describes how the designed Framework (the IGIF) was iteratively developed synthesised and prototyped via a two-dimensional case study – regionally within the continent of Africa, and nationally within the country of Ethiopia. The Chapter provides an overview of Africa as a continent in transition, its geospatial history within the context of United Nations and related processes, including NSDI development, and then focuses on a series of pan-African consultations and workshops that formulated, refined and validated the IGIF presented in Chapter 7. In this process, the IGIF challenges the limitations of the more traditional (first and second generation) approaches to NSDI development and implementation. The Chapter then demonstrates the application and usefulness of the IGIF nationally within Ethiopia. The case study demonstrates how geospatial information can be integrated into national sustainable development policies and strategies. It also considers the role of the NSDI, as the national geospatial information system of the sustainable development data flow framework, as a means to provide reliable fundamental geospatial data, and to provide both the enabling platform and connection point to other national information systems, and to the SDGs.

8.2 Africa – A Continent in Transformation

While subjected to a long history of development challenges, Africa is now a continent in transition and transformation. African leaders are committed to a forward-looking vision for 50 years, having signed up to two important development agendas: the African Union’s Agenda 2063 and the 2030 Agenda for Sustainable Development. While these combined aspirations are ambitious, they comprise the political proclamations that must be followed while bringing about practical policy changes, which, in turn, point in the direction of structural transformation. This transformation is inherently complex, as economic growth, on its own, has been insufficient for transforming Africa thus far (Lopes, 2019). The continent of Africa is a multicultural society that is endowed with an abundance of systematic knowledge, dynamic cultural practices, human and natural resources and valuable attributes that can be used as a stepping stone towards achieving collective development (Ogungbure,

2011). Continued change requires analytical approaches and methodological tools that consider a cognisance of history, social structure, geographical and cultural context, and political will, to frame the institutional framework of political action and policy for the second-largest and second-most populous continent on Earth.

Africa is making steady progress in building the critical ingredients for sustainable and resilient societies, but the pace is slow (UNECA, 2018). With an estimated population in 2016 of 1.2 billion people, Africa is home to 54 countries, including 33 of the world's LDCs (Figure 8.1). Population varies greatly between the countries of the region, with Nigeria (182.2 million) comprising 15.3% of the population of Africa in 2015¹⁸, followed by Ethiopia (99.4 million) at 8.3% and Egypt (91.5 million) at 7.7%. The 10 most populated countries make up 61% of Africa's total population. Figure 8.2 indicates the countries that made the biggest contribution to Africa's population growth in the period 1980-2015 (UNECA, 2016a).

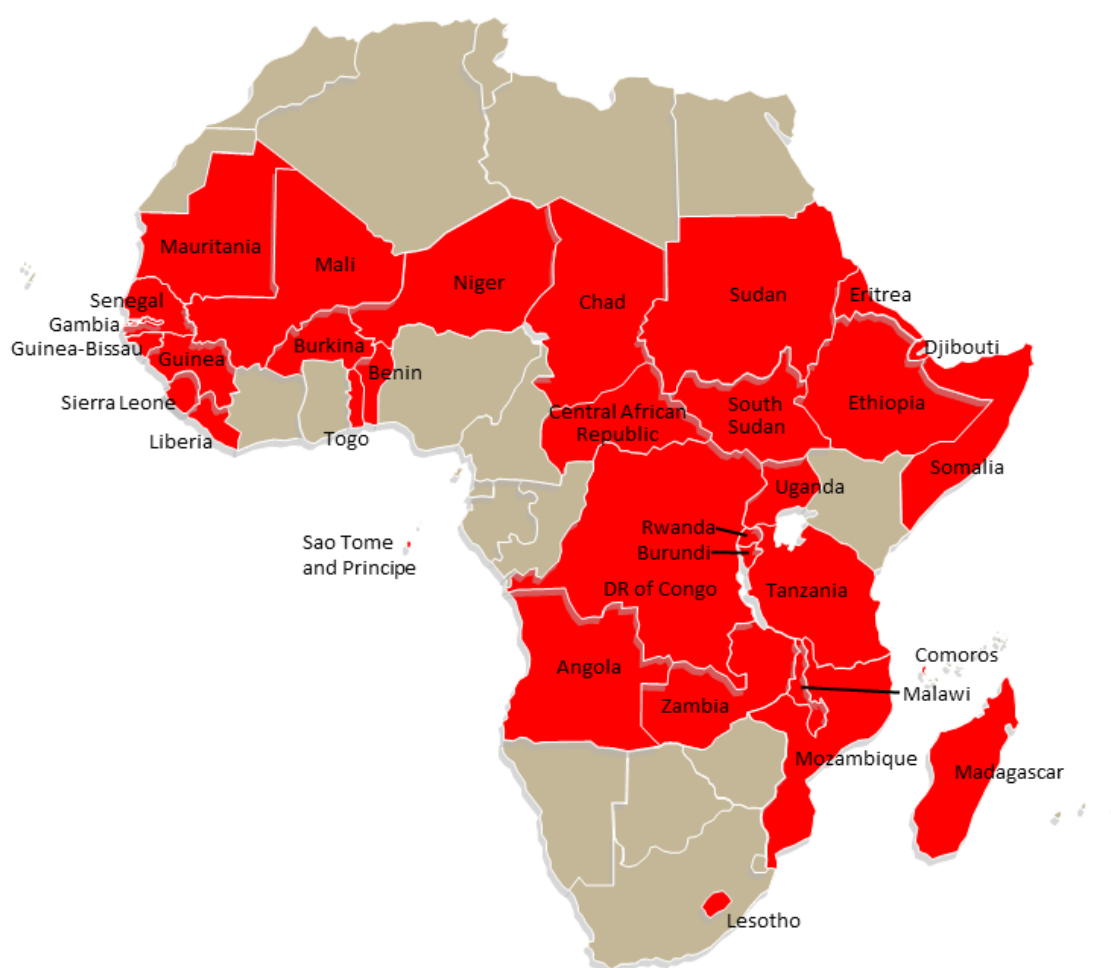
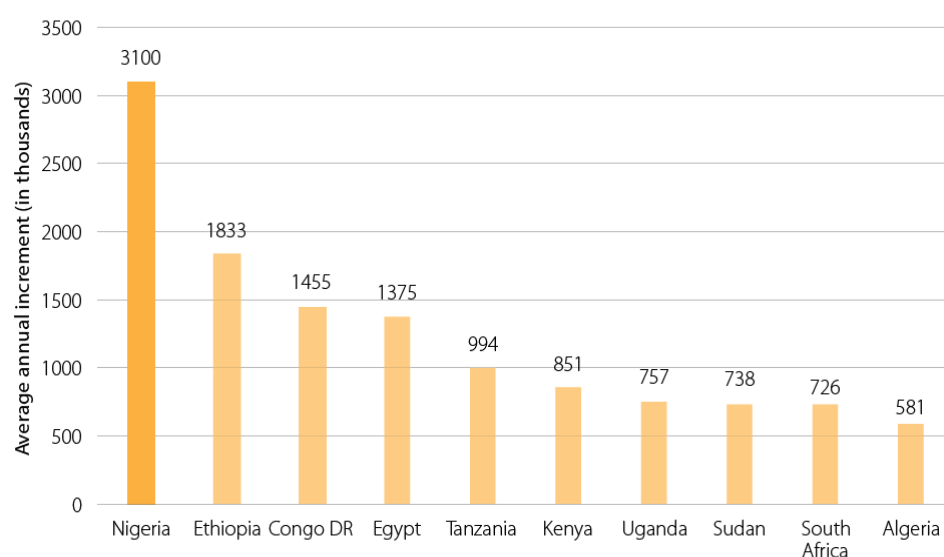


Figure 8.1: With an estimated population in 2016 of 1.2 billion people, Africa is home to 54 countries, including 33 of the world's LDCs, as illustrated in red (UNECA, 2016a).

¹⁸ This is the latest population data available for Africa, and reflects the difficulties associated with the capacity of national statistical offices and data systems to ensure access to high quality, timely, reliable and disaggregated data – even though it is a fundamental requirement of the 2030 Agenda.

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Africa is experiencing significant changes and development transformations that will affect its future population and development prospects. These include maintaining the pace of economic growth and deepening the structural transformation of economies, ensuring inclusiveness, continuing high population growth, increasing urban growth, and migration (UNECA, 2016a). While the rapid pace of urban development in Africa has the potential to advance the continent's industrial development, capacities for urban planning need to be strengthened to reverse the current pattern of urbanisation which is fuelling the proliferation of slums and undermining the potential benefits of urban growth (UNECA, 2018).



Source: ECA, based on Department of Economic and Social Affairs data (2015).

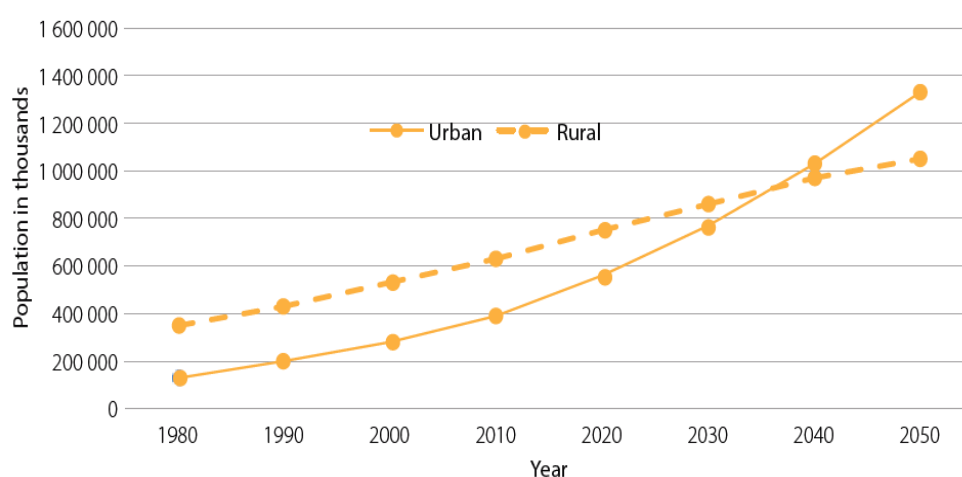
Figure 8.2: Top 10 contributors to population growth in Africa from 1980 to 2015 (UNECA, 2016a).

In 2015, 40.4% of the African population was estimated to live in urban areas, compared with 26.7% in 1980, which ranks Africa as the least urbanised continent in the world. However, the number

¹⁹ This is the latest population data available for Africa, and reflects the difficulties associated with the capacity of national statistical offices and data systems to ensure access to high quality, timely, reliable and disaggregated data – even though it is a fundamental requirement of the 2030 Agenda.

of urban dwellers in Africa nearly quadrupled over the past three decades, rising from 127.8 million in 1980 to 471.6 million in 2015 (UNECA, 2016a). Moreover, Africa is now the world's fastest urbanizing region, and is expected to increase by 867 million people over the next 35 years, rising to 1.34 billion people by 2050 (Figure 8.3), by which time about 56% of Africa's population is projected to be urban (UNECA, 2016a).

In terms of technological advancement, the *2018 Africa Sustainable Development Report: Towards a Transformed and Resilient Continent* (UNECA, 2018), emphasises that most African countries have not yet made the requisite investments in science, technology and innovation (STI) that are needed to transform their economies. The report particularly recognises that “*STI are key drivers of development and constitute an opportunity for most African countries to leapfrog to middle and upper income countries. As latecomers, developing countries need not reinvent the wheel. They can use existing technology to address their development challenges simply by building the capacity to find, adapt and adopt mutually agreed upon terms, and proven off-the-shelf technology developed elsewhere*” (UNECA, 2018, p. 102). Moreover, the STI infrastructure, such as broadband internet access, access to electricity, telecommunication and transport networks, are weak (UNECA, 2018).



Source: ECA, based on Department of Economic and Social Affairs data (2014).

Figure 8.3: Urban and rural population of African countries from 1980 to 2050 (UNECA, 2016a).

Ogungbure (2011) argues that Africa cannot make real progress in this quest if the dynamism of culture is not applied. In addition, there is the need for self-reawakening and reorientation that will place more value on the technological products of local industries. Thus, there is a need to pursue an agenda in Africa that will encourage the sophistication of cultural practices that would bring about the development of a culture of technology. In this process, policy makers and governments in Africa must promote and adopt technology via the eyes of African culture, which can assist critical social change (Ogungbure, 2011).

This culture is reflected in *Agenda 2063: The Africa We Want* (African Union, 2015), Africa's blueprint and master plan for transforming Africa into the global powerhouse of the future. It is the continent's strategic framework that aims to deliver on its goal for inclusive and sustainable development and is a concrete manifestation of the pan-African drive for unity, self-determination, freedom, progress and collective prosperity (African Union, 2015). The genesis of Agenda 2063 was the realisation by African leaders that there was a need to refocus and reprioritise Africa's agenda (from the struggle against apartheid and the attainment of political independence for the continent, which had been the focus of the Organisation of African Unity, the precursor of the African Union) towards inclusive social and economic development, continental and regional integration, democratic governance and peace and security amongst other issues aimed at repositioning Africa to becoming a dominant player in the global arena (African Union, 2015).

The need to envision a long-term 50 year development trajectory for Africa was seen as important, as Africa needs to revise and adapt its development agenda due to ongoing structural transformations, including: increased peace and reduction in conflicts; renewed economic growth and social progress; the need for people centred development, gender equality and youth empowerment; changing global contexts such as increased globalisation and the ICT revolution; the increased unity of Africa as a global power capable of rallying support around its own common agenda; and emerging development and investment opportunities in areas such as agri-business, infrastructure development, health and education as well as the value addition in African commodities (African Union, 2015). All African countries are intrinsically aligned to Agenda 2063, which must be recognised within the national policy context for all African countries in their transformation aspirations.

Africa's relevance within the 15-year 2030 Agenda timeframe is primarily limited to the specific challenges that the most vulnerable countries, and in particular, African countries, and the countries in special situations, face in their pursuit of sustainable development. However, the 2030 Agenda advocates for South-South cooperation to promote access to STI by developing countries on mutually-agreed terms (Target 17.6). It also calls for the development, transfer and diffusion of environmentally-friendly technologies (Target 17.7) (United Nations, 2015a). Target 17.8 underscores the need to fully operationalise the Technology Bank and STI capacity-building mechanism for LDCs by 2017 and enhance the use of enabling technology, in particular information and communications technology (United Nations, 2015a; UNECA, 2018).

The *Addis Ababa Action Agenda on Financing for Development* reaffirms the need to achieve a positive socio-economic transformation in Africa. It notes that the creation, development and diffusion of new innovations and technologies and associated know-how, including the transfer of technology on mutually agreed terms, are powerful drivers of economic growth and sustainable development (United Nations, 2015e). However, it noted the persistent 'digital divide' and the uneven innovative capacity,

connectivity and access to technology, including information and communications technology, within and between countries (United Nations, 2015e).

As discussed in Chapters 3 and 5, the digital divide is taking on more relevance as new ‘digital’ topics and paradigms emerge – including digital transformation, disruptive technologies, and the Fourth Industrial Revolution. These provide a further window of opportunity for the developing world, and in particular Africa, to catch-up in terms of social and economic development by enhancing growth through technological advances. The most competitive and advanced countries in Africa provide a very good basis for technological leapfrogging, and have already embarked upon a path-creating leapfrogging process (Gross, 2019). However, the translation of technological leapfrogging into economic growth is hampered by infrastructural problems, even in the most competitive countries. Policy recommendations provided include enhancing the creation of business- and investment-friendly environments in less competitive countries to build a better basis for technological leapfrogging as well as investments promoting interregional projects on improving infrastructure, human capital, governance as well as economic stability throughout the growth process (Gross, 2019).

8.3 Africa – The Geospatial Journey

8.3.1 UNECA and UN-GGIM Africa

Since its establishment in 1958, UNECA, in collaboration with national mapping agencies and other partner institutions from the international community, has been playing a lead role in assisting African governments and their specialised institutions to turn cartography and mapping, remote sensing and geospatial information science into real opportunities for Africa’s advancement in the socio-economic domain, and in sustainable development (UNECA, 2017). Chapter 3 (Sections 3.7 and 3.8) of this dissertation details this history within the United Nations geospatial information processes, and its related SDI development challenges. Chapter 5 highlights the challenges in bridging the geospatial digital divide in the African context, and Chapter 6 discusses the fundamental baseline data needs and the required ‘data flows’ that go with these needs.

Following the establishment of UNECA, the pan-African process was initiated in the early 1960’s with the first United Nations Regional Cartographic Conference for Africa being convened in 1963 in Nairobi, Kenya. However, a lack of participation by Member States, due almost entirely to a lack of funding, saw the Conference transition into CODI in 1997. CODI was then renamed CODIST in 2009, with one of its subcommittees, CODIST-Geo, providing the geospatial information convening mechanism for Africa. CODIST-Geo put considerable effort into the development of an SDI in Africa through to the establishment of UN-GGIM Africa in 2015.

UN-GGIM Africa, with ongoing Secretariat support from UNECA, continues to make progress in providing African countries with as much opportunity as possible to make substantive headway in

their geospatial development paths. These efforts are anchored to the 2030 Agenda and Agenda 2063, each emphasising the need for a global coordination mechanism for geospatial information management. Although the two Agendas have much in common and are mutually supportive and coherent, Agenda 2063 is more specific to the needs of Africa (UNECA, 2016b).

In the past few years, key areas of technical focus have included: the integration of geospatial and statistical information (UNECA, 2016b); fundamental geospatial data themes; the African geodetic reference frame; institutional arrangements and legal frameworks; and capacity and capability development (UNECA, 2019b). It is this last effort, capacity and capability development, which has proved to be the most difficult. The objective is to strengthen and harmonise human resources development and institutional capability across Africa, endeavouring to foster geospatial information literacy, geospatial information awareness and navigational abilities – promoting infrastructural capabilities (UNECA, 2016b).

In establishing UN-GGIM Africa, it was observed that *“the issues of funding, sustainability and awareness are dependent on one another. Numerous geospatial initiatives have commenced in Africa over the years, with many of them failing to realise their full potential or be sustained. There are many reasons for this, but ultimately it can be attributed to an inability to secure the necessary funding or support, which in part is reliant on making stakeholders aware of the potential benefits”* and *“the presence and utilisation of geospatial information at the community level has become extremely pervasive and is growing. It is, therefore, the responsibility of the geospatial community to raise and maintain awareness about where the data come from and why they must be constantly updated to be effective and efficient. The benefits arising from geospatial information must be communicated to feed into the sustainability and funding aspects of the initiative”* (UNECA, 2016c, para 42 and 45). Capacity development continues to be the critical issue for African countries. The gap between the developed and developing countries has continued to widen, and contrary to the motto of the 2030 Agenda, to leave no one behind, Africa countries are being left behind (UNECA, 2019c).

8.3.2 Regional Centre for Mapping of Resources for Development (RCMRD)

Another established regional geospatial initiative in Africa is the Regional Centre for Mapping of Resources for Development (RCMRD), established in 1975 under the auspices of UNECA and the African Union. Based in Nairobi, Kenya, RCMRD is a non-profit intergovernmental organisation and currently has 20 participating Member States in the Eastern and Southern Africa Regions (RCMRD, 2020). As a regional centre of excellence, the mission of RCMRD is to promote sustainable development through generation, application and dissemination of geo-information and allied ICT services and products in member states and beyond. Since its establishment, the Centre has been instrumental in capacity building in resource survey, mapping, remote sensing, GIS and natural resources assessment and management in Africa. (RCMRD, 2020).

RCMRD has been closely aligned with the geospatial capacity and capability concerns expressed by UN-GGIM Africa and its predecessors for decades. Former RCMRD Director-General, and now Governor, Wilber Ottichilo framed the issue in 2006 as follows: *“This data and information is important and crucial for sustainable development of developing countries, particularly African countries. However, the use of this data and information in Africa is still limited due to numerous reasons. Among the reasons are lack of awareness among planners and decision makers of the importance of geo-information in sustainable development, inadequate capacity (qualified human resources and facilities-hardware & software), lack of institutional and policy arrangements, data accessibility problems, uncoordinated application of geo-information technologies in sustainable development as well as in the development Spatial Data Infrastructures (SDI) etc.”* (Ottichilo, 2006).

8.3.3 Africa Action Plan 2016-2030

Within the Africa context, there are two regional SDI initiatives underway, both led by UN-GGIM Africa and supported by UNECA. The first, the *Geospatial Information for Sustainable Development in Africa: African Action Plan on Global Geospatial Information Management 2016-2030* (African Action Plan), is the geospatial implementation tool for UN-GGIM Africa. This document responds to the recommendation of the Africa preparatory meeting (GGIM Africa) held in Addis Ababa in August 2011, urging Member States, UNECA and the African Union Commission to finalise and implement an African Action Plan on Geospatial Information Management (UNECA, 2017).

A mechanism to coordinate the geospatial information management needs of the 2030 Agenda and Agenda 2063 for Africa, the African Action Plan focuses on four key areas of implementation: geospatial information policy and governance; common framework and tools; capacity building and knowledge transfer; and international coordination, collaboration and cooperation in meeting regional and global needs (UNECA, 2017). It also contains a specific action area: integration of geospatial information and statistics. Each focus area, including the integration of geospatial information and statistics, is set out in detail in the Action Plan, inclusive of specific objectives, expected results, estimated budget figures and related activities. Significantly, the African Action Plan outlines the essential actions with related responsibilities, timescales and costs that will steer the future implementation of the initiative in Africa. For the period from 2016 to 2030, the Action Plan has determined a total required provisional budget of US\$154.3 million (UNECA, 2017). At the time of writing this dissertation, none of this aspirational budget had yet been realised.

The African Action Plan articulates well the African position and status on the four key focus areas, and offers strategies to resolve the associated challenges, including in geospatial governance, policy and frameworks. The conceptual framework of the African Action Plan at the national level is provided in Figure 8.4. The framework requires fit-for-purpose tools, information products and services to be translated to support the SDGs and Agenda 2063 Targets (SATs). Geospatial information, as well as statistical information, integrated via the national statistical-spatial framework (NSS) is needed to set

these SATs as shown on the schema. Once the SATs are set, the tools, products and services can be jointly identified and developed using an integrated process, combining statistical and geospatial information, with the support of the national ICT enabled environment – in particular Internet access, IT platforms, e-services, etc. (UNECA, 2017).

However, while this schema sketches the framework that will be used to provide decision support inputs to the sustainable development efforts during the period of the Action Plan, it still lacks a more targeted overarching and holistic strategic framework. In addition, it is also about systematically focusing on the means of implementation considering issues like finance, technology, capacity building, trade, policy coherence, partnerships, data, monitoring and accountability. For an effective integration, a clear integrated strategic direction, which takes into consideration national realities and regional peculiarities, is required. The challenges of developing such an integrated approach – a fit-for-purpose geospatial data framework - is proving difficult for many decision makers around the globe. This is, however, acute in developing countries, especially the African countries (Agunbiade et al., 2019).

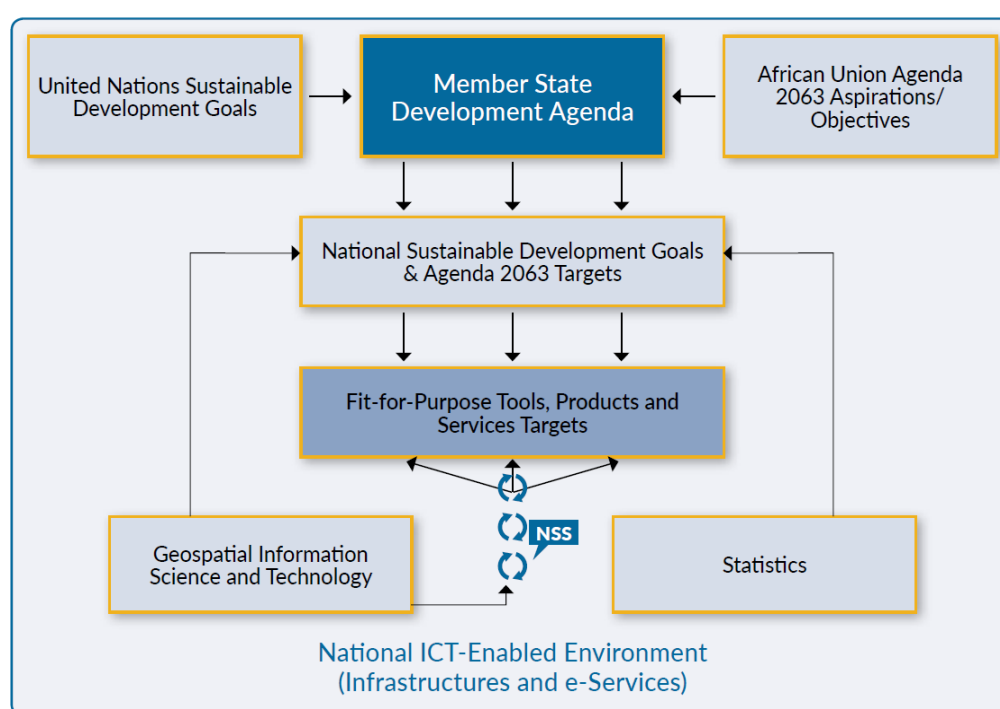


Figure 8.4: Conceptual framework of the African Action Plan at the national level (UNECA, 2017).

8.3.4 Guidelines for Implementing NSDIs in Africa

A more detailed African NSDI initiative is the project, *Strengthening the Capacities of ECA Member States to Develop Geospatial Information Services in Support of the Implementation and Monitoring of the Sustainable Development Goals: Guidelines for the Implementation of National Spatial Data Infrastructure in African Countries* (UNECA, 2019c). Written by a very well-qualified expert, Mr. Sultan Mohammed Alya, previously Director General of the Ethiopian Geospatial Information Agency and Chair of UN-GGIM Africa, these guidelines recognise the past efforts and

unsuccessful attempts to develop and progress NSDIs in Africa, and provides a modernised framework for the step-by-step implementation of an NSDI based on the current and specific conditions of African countries. Despite numerous NSDI implementation efforts in African countries for almost 20 years, the guidelines conclude that implementations to date have been ‘bottom-up’ and lacked meaningful participation and input from the relevant stakeholders and high-level decision-makers as champions and contributors. This has resulted in Africa lagging further behind other regions and, in fact, widening the geospatial digital divide between the developed and developing countries. The assessment concludes that African countries need to change course and follow a ‘top-down’ and ‘product-based’ NSDI implementation approach by involving and engaging high-level decision-makers and champions from the start.

According to Rajabifard et al. (2002), the product-based model represents the main aim of an SDI initiative being to link existing and upcoming databases of the respective political/administrative levels of the community. Chan et al. (2001) provides a detailed description of the production aspect of SDIs in terms of spatial data, value-added services and end-users, describing the chain of spatial data flow in the environment of multiple ‘production lines’. As detailed in Chapter 3, Section 3.7, SDI development approaches have evolved as a continuum over the past two decades – from product based (first generation), to process-based (second generation), to user-centric (third generation) SDIs that recognise synergies with citizen-generated data, and additional characteristics such as financial, capacity building and communication as additional key components. However, while contextually capturing all of the key elements and motivations described previously in this Chapter, the NSDI core components described in the guidelines do remain essentially the same, although updated, as first proposed by Rajabifard et al. (2002) almost 20 years ago (detailed in Chapter 3, Section 3.7).

The challenge is, that while the SDI theory and continuum has continued to evolve and develop in both theory and practice in much of the developed world, including addressing most of the new components a long time ago (take INSPIRE as but one example), the developing world has not had the same opportunity to do so. Consequently, Figure 8.5 presents these long-standing NSDI components within the guidelines, but now inclusive of 15 key indicators/variables selected as the most relevant for the assessment of the NSDI status in African countries. While elements such as national governance, leadership, finance, innovation, capacity building, partnerships, and communication and engagement are not captured, the guidelines do begin to develop a strategic plan and roadmap, inclusive of a vision, mission, goals and objectives. While still in development, this has proved a valuable contribution to the guidelines for African countries and frames the relevance and importance of the implementation of the IGIF within the continent of Africa.

8.3.5 Iteratively Developing the IGIF with African Countries

The research problem, aims and objectives described in Chapter 1 (Section 1.2) included the requirement to demonstrate the utility and implementation of the Framework via a case study. Given

the context of the research problem and aim, that ‘developing countries’ are those most affected by the challenges to achieve national development, the case study for this research is primarily the continent of Africa. The previous two sections demonstrate Africa’s desire to develop and adopt common frameworks and tools that support capacity building and knowledge transfer in geospatial information management, but also the same desire to modernise approaches, or to at least have a robust discussion on options and strategies going forward. This desire will be reflected in this African case study development of the IGIF. Further, given the need to ensure ‘national implementation’ the case study also delves into a country example, Ethiopia, to extract some of the pertinent issues in solving the research questions. The case study of Ethiopia will be presented in Section 8.4 of this Chapter.

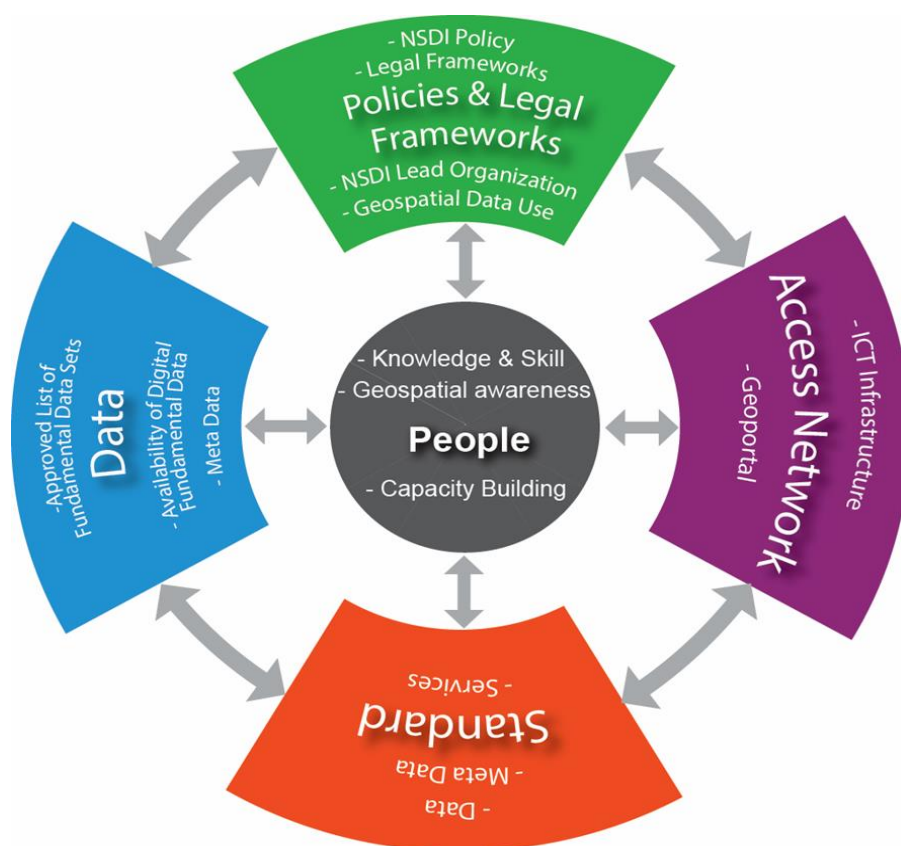


Figure 8.5: NSDI components with 15 key indicators/variables most relevant for the assessment of NSDI status in Africa (UNECA, 2019c).

The case study research strategies adopted in Chapter 4 (Section 4.4.8) provided the researcher with the means to develop, iterate, prototype and demonstrate the IGIF with a large grouping of national geospatial experts from African countries. The required information and data collection for the case study was mainly collected in a number of highly interactive and structured regional workshops and consultations undertaken in close collaboration with and support from UN-GGIM Africa and UNECA. This was seen as the most efficient way to iteratively develop and then test the IGIF.

8.3.5.1 Consultation 1: Addis Ababa, Ethiopia, April 2018

The first consultation and workshop was convened at UNECA's Headquarters in Addis Ababa, Ethiopia, from 26-27 April 2018, prior to the consideration and adoption of the IGIF by UN-GGIM. This was the very first exposure by any regional grouping of countries to either the Strategic Framework or the IGIF. From 17 African countries²⁰, the 25 participants were primarily Director General's from National Mapping and Geospatial Agencies (Figure 8.6). On the first day, participants discussed the virtues of the NSDI, fundamental data themes, and the Integrated Geospatial Systems Framework (as presented in Chapter 6) – as an integrative data ecosystem – and how this can be applied to the SDGs with fundamental data. Interestingly, participants focussed on key issues, challenges and other 'road blocks'. These included, in no particular order: policy and awareness; technology infrastructure; availability of fundamental data; delivery of the data, including data sharing; leadership and political buy-in; how to build the right institutional framework; the value of geospatial information; and how all of this fits with Agenda 2063. It is important to note that these topics were discussed at length, before the researcher had even introduced the group to the IGIF!

On the second day, participants were introduced to the first draft iteration of the IGIF. At that time the Framework was presented more as a series of descriptions and component areas for discussion rather than a more defined Framework. The intent being to not imply that the Framework was already prepared, but to illicit as much information as possible from participants. This was beneficial, as the African countries were able to voice their opinions and concerns towards ensuring that the Framework is organised in such a way that it could be readily used as guidance to establish a geospatial information management system within their respective countries. The main observations and inputs from the African group included the following, again in no particular order:

- It is understood that the Framework is written for developing countries / LDCs / those with the least infrastructure and capacities;
- Understanding is that the Framework is to recognise and overcome key capacity and capability challenges that we have in developing geospatial information management at regional or national levels;
- Are we expecting guidelines, cookbook, or a manual for geospatial information management in our countries;
- The Framework needs to address the issue of implementing an integrated geospatial information management system in our countries;
- What needs to be implemented must come out clearly. Otherwise it is not implementable.
- There is a need for further in-depth consultation at a national level to fully record user needs and requirements;

²⁰ Algeria, Botswana, Burkina Faso, Cameroon, Cote d'Ivoire, Ethiopia, Madagascar, Mozambique, Namibia, Niger, Senegal, Seychelles, South Africa, South Sudan, Tunisia, Uganda and Zambia. Other participants were from the United Kingdom, UNECA, RCMRD, and UNSD.

- The Framework does not provide the detail on how to translate the broad concepts and principles to concrete actions on the ground. We need more prescriptive guidelines on the application of data, including actions and costs. We cannot define those concretely without investigating user needs and holding a requirements assessment at a national level;
- How does it align (with the Africa Action Plan)? We need consistency in terms of implementation. Africa is battling with data, most are implementing a product-based NSDI. Why are we moving from this challenge to a process based Framework?
- Funding and financing is a main problem in getting geospatial initiatives to be studied and implemented. This is a good start to getting financial institutions and partners engaged, and is a very good thing;
- The importance of partnerships and international cooperation should be reflected in the Framework. Sometimes they are our only means to support national development and capacity building activities;
- In terms of developing an NSDI nationally across Africa we already have guidelines, including for developing the geodetic reference frame. We request that these things are taken into consideration. We need a deeper consultation from Member States at a national level;
- Not all components are equally important. They are not ‘in balance’ - we need to identify the ones which are more important, urgent and relevant. These are all the basis for geospatial information management in developing countries; and
- It should be made clear that this does not replace a national level NSDI, but is a means of getting donors to be interested in geospatial information. It gives a means, particularly for the World Bank, to provide a global framework to assist with negotiations with Finance Ministers.



Figure 8.6: Participants at the first consultation and workshop convened at UNECA’s Headquarters in Addis Ababa, Ethiopia, from 26-27 April 2018. Much of the workshop was conducted with intermittent emergency power due to persistent power outages.

By way of summary, the African countries reiterated the importance of international cooperation and partnerships in the Framework, as it is a major goal to have well established international cooperation and partnerships that support national development and capacity building interests in situations where countries are just beginning to communicate the importance of geospatial information across national aspects. International cooperation donors require a strong business case and confidence in governance before releasing funds to countries. Given the breadth of potential audience, it was also suggested that there should be more emphasis on making the case to decision-makers and finance institutions on direct and indirect benefits, and benefits realisation, of geospatial information. This includes appreciation of the widespread benefits accruing a long time after the initial investment has been made, treating it like an infrastructure. This would ensure that decision-makers then have a fuller understanding of not only what investment is required, but what the long-term benefits may be. The strategic pathways within the Framework would need to provide a checklist of components that help deliver more sustainable programs and projects for donors, and provides a mechanism for better coordination between donors.

A noteworthy outcome of this first consultation with African countries was agreement to include the strategic pathways on financial, partnerships, and capacity and education in the next iterations of the IGIF.

8.3.5.2 Consultation 2: Addis Ababa, Ethiopia, October 2018

The second consultation was convened six months later, and shortly after the IGIF had been adopted by UN-GGIM. Again, the consultation was convened at UNECA's Headquarters in Addis Ababa, Ethiopia, from 1-4 October 2018. This time on the margins of the Sixth Statistical Commission for Africa and within the program of the Fourth Plenary Meeting of UN-GGIM Africa. Although limited to a half-day session, but with more than 70 participants, including from 18 African countries²¹ (Figure 8,7), this consultation discussed a more-defined IGIF, and one which had attempted to address many of the issues raised in the first consultation as described in Section 8.3.5.2 above. The IGIF was presented with the 7 overarching principles, 8 goals and 9 strategic pathways, as adopted by UN-GGIM, for further discussion and consideration.

As this African group was significantly larger and broader than the first consultation (Section 8.3.5.1), there was a requirement to 'repeat and revisit' the first discussions, as there were many in the room whom had no previous exposure to the IGIF. This process alone reiterated for the researcher the need to continually communicate with stakeholders and to ensure that appropriate materials were available for participants to take with them and share with colleagues in their national environments. However, the consultation achieved its objective of providing the opportunity for participants to confirm

²¹ Algeria, Botswana, Burkina Faso, Cameroon, Cote d'Ivoire, Eswatini, Ethiopia, Kenya, Madagascar, Mali, Morocco, Namibia, Niger, Nigeria, Senegal, South Africa, Togo and Uganda. Other participants were from Australia, France, UAE, the United Kingdom, RCMRD, UNECA, African Union and UNSD.

each of the strategic pathways, and to explore the details and descriptions of the 4 key elements (Chapter 7, Section 7.3.6) for each of the nine strategic pathways.

During this process, it was reiterated that the context and relevance of the 2030 Agenda, Agenda 2063, and the African Action Plan need to be captured appropriately in the IGIF if it is to successfully be implemented as an integrated monitoring and reporting framework for the data ecosystem in Africa. Understanding current national realities, desired goals and objectives, and capacity and capability development needs, were also emphasised.



Figure 8.7: Participants at the second consultation and workshop convened at UNECA’s Headquarters in Addis Ababa, Ethiopia, from 1-4 October 2018.

8.3.5.3 Consultation 3: Addis Ababa, Ethiopia, April 2019

The third consultation and workshop was once again convened at UNECA’s Headquarters in Addis Ababa, Ethiopia²², from 22-25 April 2019, exactly one year after the first consultation. Convened jointly with a UNECA Regional Workshop for African countries on the ‘Implementation of National Spatial Data Infrastructure (NSDI) in Africa’, the consultation was attended by 33 participants, including from 17 African countries²³ (Figure 8.8). This third meeting provided an opportunity to ‘road test’ and refine a mature IGIF, and to capture other additional aspects that support this dissertation’s research. These included: defining the geospatial digital divide as presented in Chapter 5; identifying the differences between the NSDI and the strategic pathways of the Strategic Framework; and reflecting on the following general questions pertaining to the IGIF:

²² Many pan-African meetings are convened at UNECA in Addis Ababa due to the availability and quality of conference facilities and flight schedules.

²³ Botswana, Burkina Faso, Cameroon, Comoros, Eswatini, Ethiopia, Ghana, Kenya, Madagascar, Namibia, Niger, Nigeria, Senegal, South Africa, South Sudan, Togo and Uganda. Other participants were from the Kingdom of Saudi Arabia, UNECA, RCMRD, UNSD, the Centre of Studies, Research, and Production of Environmental and Sustainable Development Information (CERPINEDD), the African Regional Institute for Geospatial Information Science and Technology (AFRIGIST), the World Geospatial Industry Council (WGIC) and EIS-Africa.

- Does the IGIF have the right balance, structure, and substance for implementation?
- What are the IGIF's strengths and where are its weaknesses? Where is there too much and/or too little detail?
- Does the IGIF constitute the right reference point for countries to implement and apply?
- Does the IGIF provide the ability to link with Africa and regional strategies, including the Africa Action Plan and Agenda 2063?
- Are the nine strategic pathways and their key elements right?

As a means to answer the five questions above, a SWOT²⁴ analysis exercise was initiated in three break-out groups over an entire day. The SWOT analysis was conducted for all 9 strategic pathways with the overarching question: 'What is your initial reaction to the structure, form, and content for strategic pathway 1,2,3, etc.?' While, the three groups each took quite different approaches to answering the question, the information provided, and discussions that followed in the presentations in reporting back, demonstrated the challenges in even some of the most basic needs for the African countries. A number of examples of the presentations from the groups are provided in Appendix 2.



Figure 8.8: Participants at the third consultation and workshop convened at UNECA's Headquarters in Addis Ababa, Ethiopia, from 22-25 April 2019.

A draft of the Guidelines for Implementing NSDIs in Africa (detailed in Section 8.3.4) was also presented for discussion. An immediate progression was then a discussion that questioned the differences between the NSDI Guidelines and the IGIF, and the difference between the NSDI and the strategic pathways. This very robust discussion was valuable in articulating both the needs and

²⁴ Strengths, Weaknesses, Opportunities, and Threats.

challenges for Africa in geospatial information management. It also provided an opportunity for African countries to understand the value of the IGIF to assist in overcoming the prevalent lack of ‘political will’ challenges many had identified as constraining the concepts and embracing of NSDIs in Africa. This discussion actually consumed the entire topic of implementation of NSDIs in Africa, but was not resolved. However, it will be addressed in detail in Section 8.3.5.4 below, as it formed a major topic of discussion at the final consultation and workshop.

The geospatial digital divide was presented against the backdrop that geospatial information is empowering billions of people by default – as a disruptive technology amidst digital transformation – and it is able to leverage the SDGs, smart cities, location analytics and business intelligence, construction and engineering, the environment, and emerging technologies such as AI, the IoT, Big Data, Cloud computing, Blockchain, and others. This is not the reality in Africa (Figure 8.9). For African countries, realising digital transformation and geospatial technology by ‘default’ remains out of reach. Participants emphasised that Africa does not yet have the ‘opportunity’ to attain effective and sustained access to the vast amounts of data, digital technology, the Internet (or even electricity) and the corresponding computer literacy that is needed to contribute to the global information society and accelerate human progress (Scott and Rajabifard, 2019).

The concept of bridging the geospatial digital divide, and particularly the ‘gaps’, provided an opportunity for African countries to understand the value of the IGIF as a strategic communication mechanism, and the meaning of the geospatial digital divide. It provides a means to assist in overcoming the prevalent lack of ‘political will’ challenges many countries identified as constraining the concepts and embracing of NSDIs in Africa. It was recognised that changing and elevating the message and perspectives will be critical to growing political knowledge and understanding. The discussions on ‘bridging the geospatial digital divide’ were so well received by participants that it was requested to be included as a key element within the strategic pathway on Innovation (see below).

The disruptive nature of digital transformation?

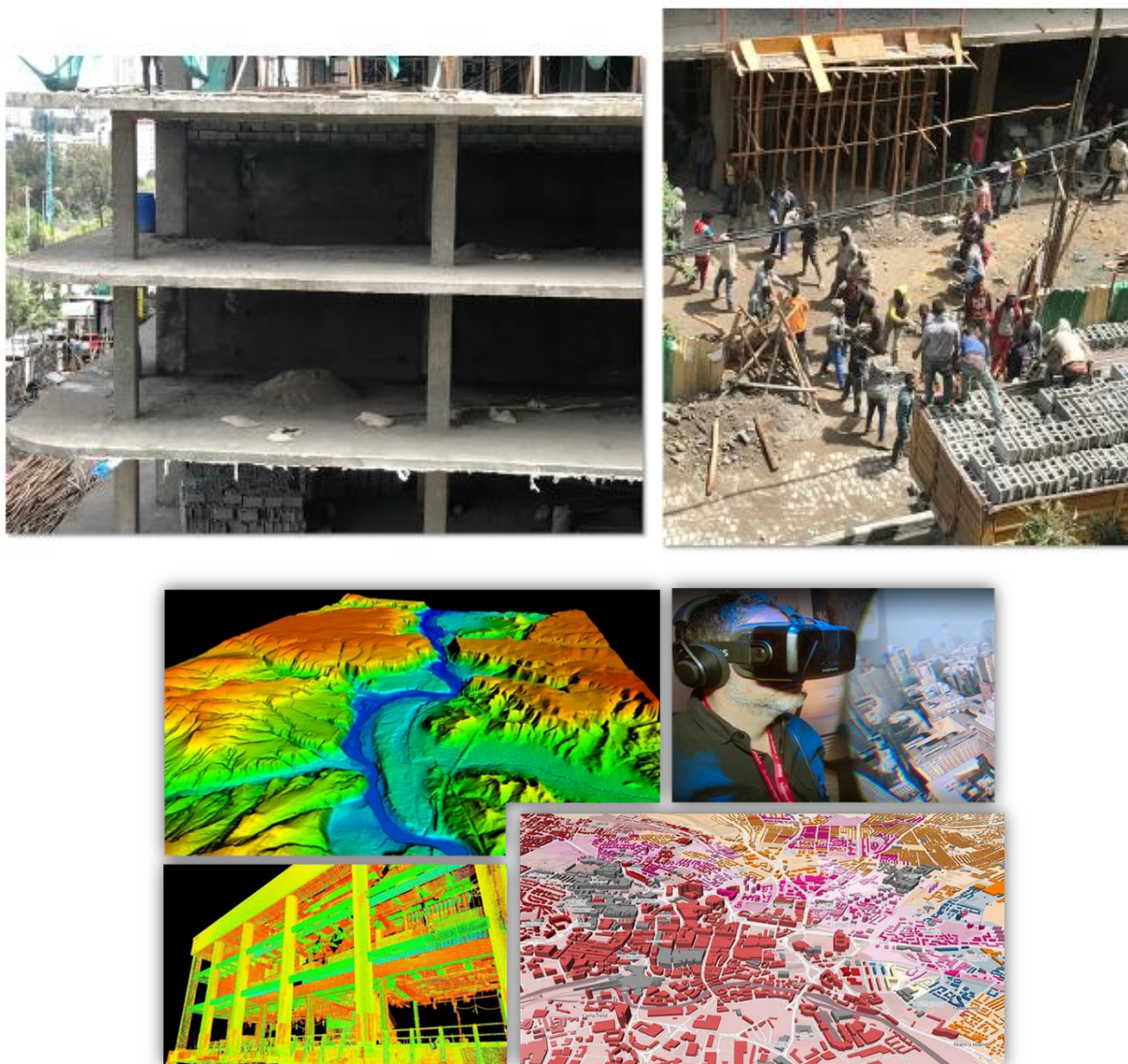


Figure 8.9: Slides used to highlight the disruptive nature of digital transformation, so prevalent in the developed world, but which almost does not exist in Africa. Building construction photos taken by researcher near UNECA Headquarters, April 22, 2018.

Regarding the refinement of the IGIF's strategic pathways and key elements, the valuable and engaging consultation can be summarised as follows:

Strategic Pathway 1: Governance and Institutions

- Countries view Governance as one of the highest importance of the strategic pathways;
- The group noted that good governance in Africa is critical. They noted that UNDP has a definition on governance; referring to the political, economic and administrative arrangements in a country;
- A strength of this pathway is that it provides a means for countries to impose/order arrangements or collaborations between institutions;

- Changes in government influence institutional stability and could impact/influence continuity of national geospatial development;
- This pathway will help in reducing cost of governance by either avoiding duplication of acquisition and/or the management of the data; and
- The group recommended that the key element ‘Institutional Structures’ be changed to ‘Institutional Arrangements’.

Strategic Pathway 2: Policy and Legal

- The group determined that having appropriate policy in place as being critically important, and even considered elevating this pathway to strategic pathway 1. However, following broader discussion among the group, it was agreed that the strategic pathways should remain in the present order. But the group recommended that the pathway should be renamed from ‘Legal and Policy’ to ‘Policy and Legal’.
- The group discussed how to ensure the security of sensitive data (highly sensitive data, unmaintained data, etc.);
- The group noted the narratives of implementation and accountability, that these need more clarification, and that Data Protection and Licensing should be less ambiguous;
- The group recommended that two elements should be modified: Policies, Norms and Guides; and Data Protection, Licensing and Sharing; and
- The group recommended that privacy needs to be included in the narrative.

Strategic Pathway 3: Financial

- The group was not clear what was meant by Business Model? It is important to make a business case to show benefits. Does it mean that?
- The group recommended changing ‘Investment’ to ‘Sources and Means of Financing’, as there is a need to understand the return on investment (sources and means of financing) and benefits realisation;
- To implement and finance in geospatial information, there is a need to know what we are investing in. We need to know where we are lagging behind; and
- The ‘public good’ value of data needs to be recognised in financial considerations.

Strategic Pathway 4: Data

- The group discussed changing the sequence (Acquisition, Custodianship and Maintenance), but it was agreed that custodianship has to be in place (someone in charge) before acquisition can occur;
- The group was unclear on some of the terminologies used, especially data supply chain interlinkages. They recommended that the intent of Data Supply Chain Interlinkages and Data Curation and Delivery be combined to one element. They recommended a new fourth element on Data Security;
- The group noted that most data in Africa does not have metadata. They recognised that they need data and metadata, especially as fundamental datasets;

- There was concern raised about maintaining the data value chain through the data integration process, particularly for the secondary level data;
- It was recognised that data completeness (coverage and characteristics) are concerns for Africa, which is also related to data quality and the accuracy of that data; and
- The group noted the important role of coordination when engaging data providers to ensure consistency, coverage and quality of the data, and to avoid duplication.

Strategic Pathway 5: Innovation

- The group suggested that the additional text be included: “The objective is to stimulate the use and development of the latest cost-effective technologies, process improvements and innovations so that governments, and the broader community”;
- The group recommended that ‘Bridging the Geospatial Digital Divide’ be included as a key element, and that more clarification and expansion of the geospatial digital divide is provided;
- The group considered that an additional option is that each nation should be able to have the innovation to buy the data to process, analyse and to provide as a service (deal with the data locally) and minimise a dependency on full solutions externally;
- The group noted the need to put in place enabling infrastructures to stimulate rapid transformational change; and
- The group were not clear on what was meant by ‘creativity and innovation’ and that this needs to be considered more from an African perspective. Sometimes simple and flexible local solutions will suffice, and are innovations in themselves.

Strategic Pathway 6: Standards

- The group suggested that in the Framework it is suggested that national or regional bodies support, recognise and adopt the international standards;
- The group questioned if ‘Technology Interoperability’ is better to be used instead of ‘Technical Interoperability’;
- The group considered that the importance of ‘consistency’ of standards and their use is very essential to be mentioned;
- The group suggested that the ‘interoperability of systems’ (E-Governance) needs to be captured in the text;
- With regard to technology interoperability, the group recommended that to ensure that on semantics, it is not just machine-to-machine but also people-to-people;
- The group noted that some standards are difficult to understand and know when to apply them in an African context. There is an effort underway to translate the standards into a layman’s description in order to stop countries trying to create their own standards including for metadata – efforts going on now from ISO perspective; and
- The group recommended to ensure that national standards bodies are recognised, and that geospatial institutions need to create partnerships with them.

Strategic Pathway 7: Partnerships

- The group recommended to change ‘International Collaboration’ to ‘International, Regional and Sub-Regional Collaboration’;
- The group suggested that having partnerships which are more inclusive rather than exclusive (ensuring equal ownership and equality) should be included into the body of the text;
- The group suggested considering ‘Cross-Sector and Interdisciplinary Partnership Arrangements’ instead of ‘Industry Partnerships and Joint Ventures’, recognising that participation of community stakeholders is necessary;
- The group recognised that community engagement is important to ensure inclusiveness and ownership; the community can influence politicians;
- The group noted that while the pathway seems to address horizontal contribution, it is not clear on vertical inclusion on the leadership hierarchy for supporting the geospatial industry. The intergovernmental, as well as the different levels of government partnerships, is missing – global to local;
- The group suggested the need to include the contribution of policy-makers as part of partnerships in the hierarchical order. For example, at both parliament and local government levels; and
- The group noted that partnerships should include knowledge-sharing and capacity-building.

Strategic Pathway 8: Capacity and Education

- The group commented that geospatial science needed to be introduced into the formal education process at an early stage (e.g. intermediate classes at school), and recognising that there are different class brackets in education around the world;
- The group considered that with the ‘Awareness Raising’ element, that ‘Advocacy and Outreach Programs’ should be used;
- The group considered that ‘awareness’ should be used in the text across all sectors and communities. The group noted that education should not be exclusive for students in school, and should include professional continuous education, including on the job;
- The group commented that smart and well prepared educational materials should be available. These could include videos, short presentations, etc.;
- The group recommended that ‘research’ (research and development) be added as an element because of its importance to capacity, and as a minimum is necessary to be added to the text;
- The group suggested, and following a long discussion, switching the element in Innovation: ‘Promoting Innovation and Creativity’ with ‘Entrepreneurship’ in this pathway. However, an alternative option is that the strong interlinkage between the two should be identified;
- The group noted that knowledge management, including knowledge retention and transfer of knowledge, should be added to the body of the text;
- The group noted the value of the establishment of professional associations and organisations, as part of capacity and education; and
- Capacity is actually missing. We need to include capacity regarding people and organisational/institutional. Keep infrastructure to the technology side. Capacity is not just training. It is also the institutional; infrastructure and individuals.

Strategic Pathway 9: Communication and Engagement

- Using appropriate communication channels should be added to the text;
- The group recommended replacing the references to ‘awareness’ in the body of the text to ‘advocacy and awareness’;
- The group recommended that the pathway should have the following four elements:
 - Stakeholder Identification and User Engagement;
 - Integrated Strategic Engagement;
 - Communication Methods; and
 - Monitoring and Evaluation; and
- The group suggested to add appropriate text to capture feedback from partners and users.

The detailed inputs and perspectives from the participants greatly assisted in developing the IGIF with the appropriate focus, and was seen as being critical for changing and elevating the message and perspectives towards growing political knowledge and understanding in geospatial information management.

8.3.5.4 Consultation 4: Kigali, Rwanda, November 2019

The fourth and final consultation and workshop was convened at the Kigali Conference and Exhibition Village in Kigali, Rwanda, from 18-22 November 2019. Convened jointly with AfricaGIS 2019²⁵ and the Fifth Plenary Meeting of UN-GGIM Africa, the consultation was attended by more than 80 participants, including from 27 African countries²⁶ (Figure 8.10). The workshop provided the opportunity to engage with an expanded group of participants from African countries, and to reaffirm for the final time the structure and content of the Strategic Framework, now presented as the IGIF, inclusive of the key elements of the strategic pathways, and their descriptions. It also provided the additional ability for the African countries to start to consider how they would ‘implement’ the IGIF within their regional and national circumstances.

However, and as eluded to in Section 8.3.5.3, an in-depth discussion on the linkages of the IGIF with the NSDI formed a key topic of the meeting, particularly as the final report of the Guidelines for Implementing NSDIs in Africa (as described in Section 8.3.4 above) was presented for consideration. For African countries, this was a vitally important discussion, as many had been attempting to implement and sustain NSDI’s within their countries for up to two decades. But the political will, knowledge and understanding to embrace the NSDI concept, and the value of geospatial information

²⁵ <https://www.eis.africa/africagis-2019/>

²⁶ Benin, Botswana, Burkina Faso, Cameroon, Comoros, Cote d’Ivoire, Democratic Republic of Congo, Eswatini, Ethiopia, Ghana, Kenya, Liberia, Madagascar, Mali, Mauritania, Morocco, Mozambique, Namibia, Nigeria, Rwanda, Senegal, South Africa, South Sudan, Sudan, Togo, Uganda and Zambia. Other participants were from Australia, Canada, Japan, African Union, UNECA, RCMRD, UNSD, UNFPA, UNOOSA, CERPINEDD, African Regional Institute for Geospatial Information Science and Technology (AFRIGIST), African Association of Remote Sensing of the Environment (AARSE), Airbus, Esri, the University of Rwanda and EIS-Africa.

has simply not yet been successfully realised. As shown in Figure 8.11, and through the Guidelines for Implementing NSDIs in Africa, a new approach is being considered, albeit with older SDI theory and practice. Fortunately, the timing of this approach, with the advent of the IGIF, is opening new opportunities for countries to take a more strategic approach to addressing what has been a long and systemic issue. A session in the workshop program was dedicated to explain how the IGIF, as an integrated Framework, allows those countries that have only just started developing, or may have already implemented, NSDI capabilities to build upon this existing progress and investment.



Figure 8.10: Participants at the fourth consultation and workshop convened at the Kigali Conference and Exhibition Village in Kigali, Rwanda, from 18-22 November 2019.

With reference to the challenges depicted in Figure 8.11, as countries are being subjected to growing digital transformation and disruption, it was discussed at length that three key factors now challenge the limitations of existing NSDI implementation approaches within the context of Africa. The first is that the principal focus of NSDIs has just been focused on creating an NSDI rather than developing national geospatial capacity. While an NSDI is a core and valuable component, a national geospatial program is much more than the data. What is needed to establish or maintain an integrated national geospatial program is not sufficiently addressed by the NSDI. Past efforts at achieving an NSDI have focused on ‘creating NSDI arrangements’ rather than developing national geospatial capacity to address priority societal, economic and environmental decisions. Efforts have not been integrated into the broader requirements and mandates of government. They have tended to operate as agency silos.

The second is the recent and growing availability of more diverse data and data types and needs that are now more relevant and dependent on geospatial data than were originally considered. This reflects both technology evolution and the new and emerging data ecosystem that is more dependent on

both ‘location’ and ‘integration’. Big data, structured and unstructured data, and other realities pressure the current limitation of NSDI structures, as more of these external data add potential value to everyday queries for information. Further, while some of this data is geospatially referenced, much of it is not – but needs to be.

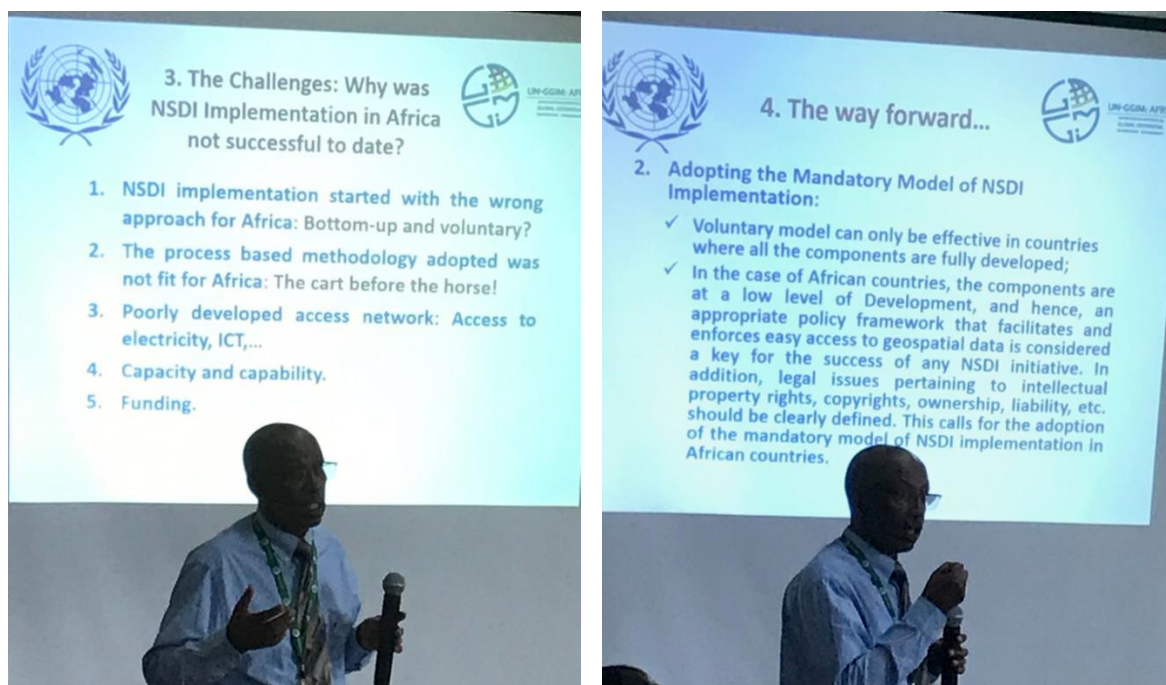


Figure 8.11: African countries discussing the Guidelines for Implementing NSDIs in Africa, led by Mr. Sultan Mohammed Alya.

The third limitation is the growing demand for data integration and analytics to deliver useable outcomes. Historically with developing countries, NSDIs have been very structured repositories (silos) of valuable geospatial information, with defined and managed (separate) datasets and themes, such as transport networks (road, rail, waterways, etc.), elevation and depth, boundaries (legal, administrative, and statistical), addresses, and water, etc. Today, there is a shift to a more user-centric and user-driven perspective. Commensurately, these data are assets that are more dynamic, and must be more flexible, readable and timely to meet diverse and specific local and national requirements; and they need to be scalable and ‘integrated’ with other data and sectors.

Specifically with regard to African countries, there is another dimension that complicates these factors – the efforts of developing countries, whom are still simply trying to establish NSDIs based on good practice, but in ways that may now be outdated and inefficient. As discussed in Chapter 3 (Section 3.7) there are lessons that the developing countries can learn from as a means to ‘leapfrog’ with more agile and lighter technology enablers. But they need guidance to do so.

As discussed at length in Chapter 3 (Section 3.5) and reiterated further in Section 8.3.4 (including Figure 8.5) earlier in this Chapter, the core components of an NSDI typically comprise

aspects of policy, access networks, technical standards, people (including partnerships) and data (Rajabifard et al., 2002). These NSDI's have historically focused on the collection of data and the implementation of technologies. Figure 8.12 compares these core NSDI components in relation to the strategic pathways of the IGIF, and highlighting the aforementioned limitations. Importantly, and as described at length in Chapter 7 through each of the strategic pathways, the IGIF does not duplicate, but builds upon and strengthens, the previous efforts and existing arrangements in planning and implementing NSDIs. In contrast to the NSDI, the IGIF is more comprehensive, additionally focusing on the governance, policy, financial, capacity and engagement processes necessary to collect, maintain, integrate and share geospatial information, through all levels of government and society, in a modern and enabling technology environment (Figure 7.6, Chapter 7). The IGIF provides a holistic, integrated national information systems-of-systems approach to the data life cycle.

The African countries overwhelmingly welcomed the expansive structure of the IGIF and its linkages with the NSDI, particularly as there is a complete absence of understanding of key messages and elements that communicate the message and need of NSDIs and geospatial information to decision and policy makers in developing countries. The IGIF is seen as being comprehensive and provides a clear vision and mission on how to develop and facilitate the utilisation of geospatial information at the national level. For developing countries, it is a valuable tool to be utilised to bridge the geospatial digital divide. Despite its comprehensiveness, the Framework is still clear enough to be used at the highest level.

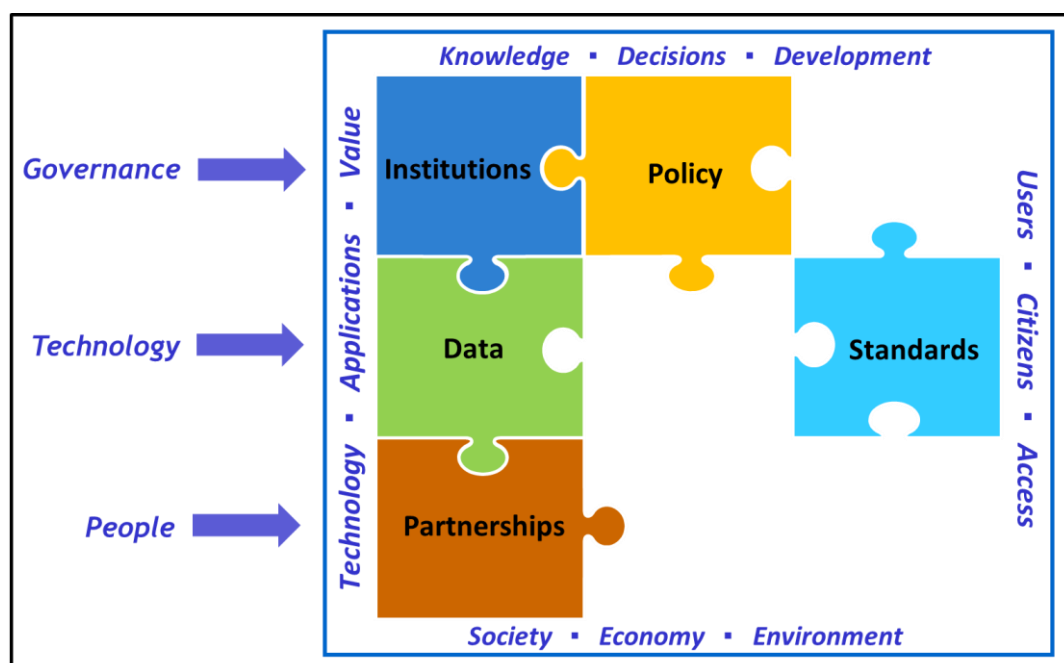


Figure 8.12: Core components of traditional NSDI implementations in comparison with the 9 strategic pathways of the IGIF (Figure 7.6, Chapter 7).

The success of the consultation workshops can be best summarised by quotes from two key supporters of this research: *“We have learned that the IGIF is the next frontier for global, regional, and national geospatial information management efforts, a new paradigm that is complementary with our NSDI initiative”* (Mr Andre Nonguierma, Chief of Geospatial Information Management Section, UNECA). *“African countries not only need to learn from the international community and good practice, they need to learn from each other. Africa is being left behind. It is not adequately mapped, and remains a long distance from being so, particularly in a systematic and sustainable way. Given the modern mapping techniques and technologies available today, why is this so? Because of the geospatial digital divide”* (Mr. Sultan Mohammed Alya, former Director General of the Ethiopian Geospatial Information Agency and Chair of UN-GGIM Africa).

8.4 Ethiopia – A Case Study

The previous sections in this Chapter detail the four interactive consultations and workshops convened over 18 months from April 2018 to November 2019 with African countries, and which were able to rigorously determine the structure and content of the Strategic Framework and IGIF presented in Chapter 7. In this respect, the majority of the aims of this research, to define, develop and test the Strategic Framework have been achieved. In fact, it could be argued that the IGIF is a direct and validated global case study test of the Strategic Framework’s development. However, as described in Chapter 1 (Section 1.2.3), a research objective was to develop a Framework that not only can be tested, but also ‘applied’ so that it can be demonstrated that the Framework can be tailored to countries for their own national circumstances and needs, while overcoming the challenges and limitations of existing methods (including NSDIs), and providing an effective mechanism for all countries going forward.

Therefore, Ethiopia has been chosen as a case study country to trial and assess the IGIF for this research. This choice is based on a number of reasons, not the least being the degree of difficulty in applying the IGIF in a developing country. Ethiopia represents one of the 33 LDCs in Africa (Figure 8.1); is the continent’s second most populated country at just under 100 million, and with commensurate high population growth (Figure 8.2); has reasonably stable governance and institutions; is easily accessible regionally and internationally and with a very good understanding of English; UNECA and the African Union are both headquartered in Addis Ababa, Ethiopia’s capital; is an ‘engaged’ country in the global geospatial community; and has a reasonably strong geospatial mandate from government. The national mapping agency supporting this research, now the Ethiopian Geospatial Information Institute, is a highly reputable institution with a long history and stability, and with much experience and persistence in attempting to establish an NSDI and related strategic mechanisms. Further, the previous and current Director Generals have demonstrated continuous pan-African leadership in UN-GGIM and UN-GGIM Africa.

With all this noted, the many impediments, barriers and difficulties in establishing and implementing more rigorous and enduring national geospatial arrangements in one of the world's LDCs, should not be underestimated. Progress is incredibly difficult, time-consuming and made in small increments, even to achieve the most basic steps and actions. The leadership within the Ethiopian Geospatial Information Institute, and its earlier incarnations, are to be congratulated for their achievements. By way of example, it is worth just noting the organisational changes of Ethiopia's national mapping agency in recent years and during the life of this research.

In 1954, the Ethiopian Government, with the support of the United States Government, established the Mapping and Geography Institute of Ethiopia to undertake survey and mapping activities in Ethiopia. The first mapping initiative of the Institute was undertaken between 1957 and 1961, in a collaborative effort between the Governments of Ethiopia and the United States to map Ethiopia at a scale of 1:50,000. In 1980, the Institute was re-established as the Ethiopian Mapping Agency by a Decree of the Government of Ethiopia (Sultan Mohammed Alya, personal communications, April 2019).

In March 2018, the Ethiopian Mapping Agency was re-established as the Ethiopian Geospatial Information Agency by Proclamation of the President of Ethiopia (Federal Negarit Gazette, 2018), and noting that geospatial information is a critical input required to ensure the continuance of the fast and sustainable development of Ethiopia. However, in October 2018, the Geospatial Information Agency and the Information Network Security Agency were combined to form the Ethiopian Geospatial Information Institute to support the growth and transformation agenda of Ethiopia. One key benefit of this merger is that the previous shared efforts in NSDI development in Ethiopia are now contained within the one single institution.

8.4.1 Ethiopian NSDI

The Ethiopian National Spatial Data Infrastructure (ENSDI) is Ethiopia's NSDI. The long history of the ENSDI, formally created by the Ethiopian Mapping Agency in 2002 (Mulaku et al., 2006) assumes that it has the potential to be a cross-sectoral data-sharing mechanism, and a key 'integrator' for the Strategic Framework. However, its stop-start history is intertwined with the many geospatial data-sharing challenges and impediments across agencies and sectors in Ethiopia. This dissertation will not revisit these, as Gemeda (2012), Mwange et al. (2018) and Gelagay (2017) have already recently documented the development and challenges of NSDIs in Africa generally, and the geospatial data-sharing barriers encountered by the ENSDI in Ethiopia specifically. Gelagay (2017) in particular, as a member of the ENSDI Program in Ethiopia, observed that because of the many institutional and data impediments already discussed in this dissertation, exploitation of the full socio-economic benefits of using geospatial information is therefore impossible in Ethiopia.

In this regard, Gelagay (2017) also advocates the same top-down approach to ENSDI development as prescribed by Mohammed in the guidelines for implementing NSDIs in Africa as detailed in Section 8.3.4 earlier in this Chapter (UNECA, 2019c). This is due to the fact that a bottom-up approach to NSDI development, whereby the initiative gains full political support after the benefits are communicated in a tangible way, cannot be realised in developing countries like Ethiopia without the full political will of the government. This, combined with a lack of coordination between organisations, poor data quality and compatibility, institutional, legal, policy, and technological issues are identified as major challenges (Gelagay, 2017).

In taking a slightly different industry perspective to geospatial development in Ethiopia, the Countries Geospatial Readiness Index (CGRI) – 2019 (Geospatial Media, 2019), first introduced in 2017 by Geospatial Media and Communications, provides annual insights into the various elements critical for the development of an integrated approach for the geospatial sector. This includes the effective contribution of geospatial information to socio-economic growth, and to achieve developmental objectives in any given country. In now reviewing 75 countries annually²⁷, the CGRI considers the merits of geospatial data infrastructure and governance to facilitate access, distribution and use of geospatial information in a country, especially institutional mechanisms like NSDIs (Geospatial Media, 2019).

In 2019, Ethiopia was ranked 57 out of 75 countries and 6th in Africa. Limiting factors included: education and awareness; data sharing; adoption of geospatial information; and use of enabling technologies. Further, it was observed that policy and decision-makers do not understand the importance of implementing suitable laws, legislations and policies for the development of a successful geospatial implementation technology. That said, it is predicted that Ghana, Ethiopia and Tanzania will lead Africa's geospatial growth and technology awareness (Geospatial Media, 2019).

8.4.2 Applying the IGIF in Ethiopia

While acknowledging the many previous geospatial implementation challenges and impediments described above, these same challenges have strengthened the resolve and commitment of the newly established Ethiopian Geospatial Information Institute (EGII), to be agents of change in Africa, to progress and exploit the full socio-economic benefits of using geospatial information, and to support the growth and transformation agenda of Ethiopia. A result of the merger of two former agencies, EGII has gone through a major structural reform. This includes a reinvigorated effort to progress the development and national relevance of the ENSDI, as illustrated in a recent portrayal of ENSDI concepts (Figure 8.13) provided by the Director General of EGII (Dr. Tulu Besha Bedada, September 2019). This effort has also resulted in a greater ability to keep up with and leverage new

²⁷ In the 2017 and 2018 CGRI, only 50 countries were included. Ethiopia was ranked 42 and 43 out of 50 respectively.

technologies, data acquisition techniques, and a valuable resource that is continually growing – not only in Ethiopia, but across Africa – skills. Young graduates and post-graduates that are eager to contribute, and are skilled practitioners (Figure 8.14).

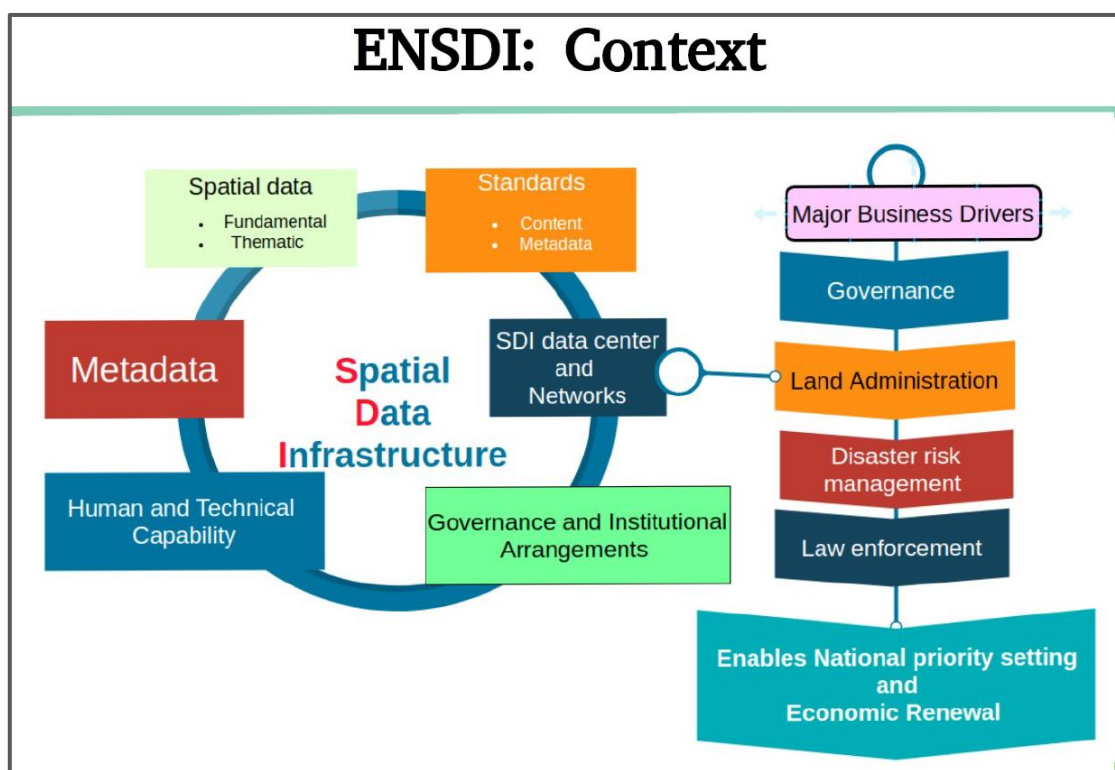


Figure 8.13: ENSDI concepts and major national business drivers for Ethiopia (EGII, 2019).

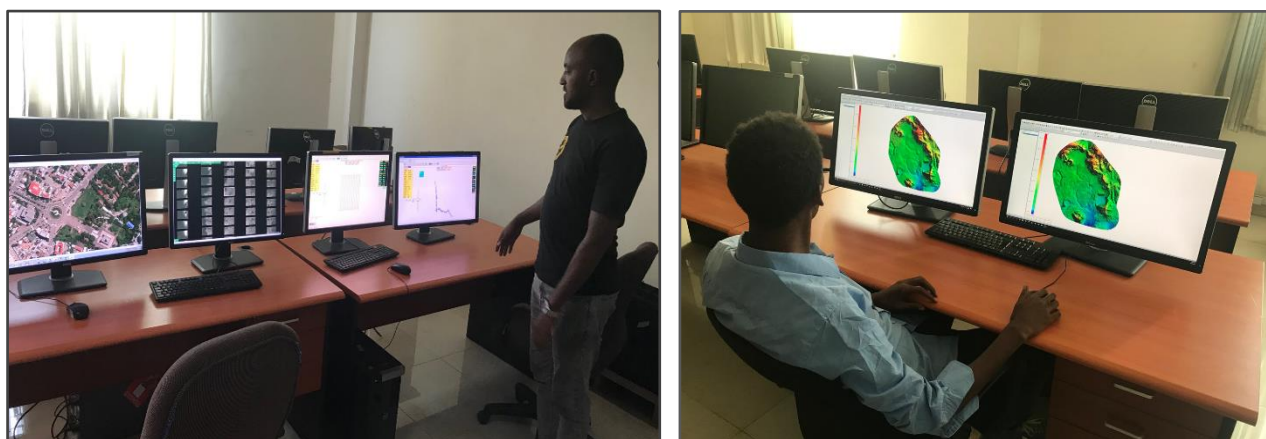


Figure 8.14: EGII is now leveraging new technologies, data acquisition techniques, and skills.

Therefore, EGII has embraced the overarching concepts of the IGIF since its very first introduction at the consultation workshop in April 2018 (Section 8.3.5.1), and when issuing the challenge that: *“the Framework needs to address the issue of implementing an integrated geospatial information management system in our countries”* and *“what needs to be implemented must come out*

clearly, otherwise it is not implementable” (Sultan Mohammed Alya, personal communications, April 2018).

The objective of the IGIF is to establish the conditions and processes that create an enabling environment where national governments can coordinate, develop, strengthen and promote the efficient and effective use and sharing of geospatial information for policy formulation and evaluation, decision-making and innovation. However, the ‘journey’ is just as important as, and in fact part of, the outcome; and it is a step-by-step approach. In order to effectively ‘implement’ the IGIF, as a forward-looking approach with a vision, mission and goals that describe a future state, the first steps are to determine where EGII is today as a geospatial organisation, and where it wants to be in the future. Therefore, a number of survey templates were provided to EGII’s senior management and related stakeholders for completion at their own pace and in their own time. The templates provided represented a subset of a larger set of templates and documents that are being prepared as part of a United Nations Development Account Project²⁸ developed and managed by the researcher in his role at the United Nations (Appendix 3). While still in ‘development and testing’, the objective is for these resources to eventually comprise the templates and documents for countries to implement their IGIF Country-level Action Plans (Chapter 7, Figure 7.4), activities beyond the scope of this dissertation.

8.4.2.1 Data Collection: Survey Templates

Data collection within the Ethiopian case study environment was primarily collected via the aforementioned survey templates for completion by national experts. At the same time, a number of informal interviews and discussions were conducted with EGII leadership and staff, including the ENSDI team, on the margins of the consultations and workshops described in Sections 8.3.5.1 to 8.3.5.4, as the Director General and key staff from EGII participated in and contributed to all four consultations. With an ambition to understand where EGII is in its ‘IGIF journey’ and in determining its level of capability to implement the IGIF and each of the nine strategic pathways, three templates were provided to capture the appropriate contextual data.

It should be emphasised that this process of eliciting this data from EGII, like that from the consultations and workshops with African countries described earlier in this Chapter, is extremely confronting and challenging. As described in Chapter 5, the lack of strategic planning skills, knowledge and opportunity, combined with the Geospatial Policy Gap, having the appropriate tools – frameworks, standards, methods and guides – is another impediment for organisations in Africa, and Ethiopia is no exception. EGII was not familiar with such business management processes and tools and the critical role that “soft” infrastructure plays in the development and execution of their business models and strategic planning. Having now worked with African countries for almost 9 years, this researcher has

²⁸ https://www.un.org/development/desa/da/individual-project-view-public/?project_id=1450&wpnonce=5be07cc988

observed that these capabilities are often underdeveloped or absent in developing countries, creating unnecessary voids in institutional knowledge and transfer.

The Current and Desired Performance Survey was used to collect information regarding both the current and desired performance of EGII. In essence, considering ‘where EGII is today, where it wants to be in the future’ and ‘what EGII needs to do to achieve the goals of the IGIF’. This survey provided data regarding the size, direction, and relative priority of performance gaps (or needs) against each of the eight Goals of the IGIF (Chapter 7, Table 7.2). As described in Chapter 7 (Section 7.3.4), the progressive achievement of the Goals will move countries towards a future state where they have the capacity and skills to organise, manage, curate and leverage geospatial information to advance government policy and decision-making capabilities, bridge the geospatial digital divide, influence inclusive and transformative societal change, achieve economic prosperity and social development, and ensure effective environmental management. Each country will have different priorities for each Goal depending on their current situation and context.

The Current and Desired Performance Survey considers EGII’s:

- **Current performance** in terms of the extent of progress towards achieving the Goals; and
- **Desired performance** in terms of national priorities.

The Survey was designed to discuss and determine the key issues related to geospatial information management in order to build a common understanding among EGII. The Current and Desired Performance Survey purpose, methods and results are provided in Appendix 4.

The Baseline Survey was used to gather detailed information about the current geospatial information management ecosystem in EGII, helping to understand gaps in current capabilities. The questions were categorised according to the nine strategic pathways defined in the IGIF. This survey literally was a method to capture and understand where EGII was in its IGIF journey towards implementation, and what areas (or strategic pathways) needed more attention than others. Because the Baseline Survey only captures a particular point in time (July 2019), it can be used to measure progress by conducting the survey again at a later date. The Baseline Survey purpose, methods and results are provided in Appendix 5.

The Environmental Scan is an assessment of the internal and external factors having an impact on geospatial information management within EGII. This provides an understanding of the broader geospatial industry environment, which may lead to the identification of new opportunities, strategies or actions to deal with any issues that are a threat to the success of the IGIF. Such a scan forces thinking about issues and opportunities that are typically beyond the day-to-day operations of EGII. These then assist in informing strategic directions that the organisation may consider and take, including whom to make strategic partnerships and alliances with, in the implementation of the IGIF. The Environmental

Scanning is achieved using the PEST and SWOT Analysis Tools. The Environmental Scan purpose, methods and results are provided in Appendix 6.

Through the above data collection processes, the researcher compiled a consolidated analysis as a Needs Assessment and Gap Analysis matrix against each of the nine strategic pathways. In this situation, a key outcome of the process is that EGII is able to use the IGIF and strategic pathways as a framework to identify opportunities and causes of problems, determine organisational priorities, and identify opportunities for overcoming gaps and moving the organisation toward its objectives – vision, mission and goals.

The Needs Assessment and Gap Analysis is divided into nine separate tables – one for each strategic pathway. Each table contains five columns. These tables and columns have been populated by the researcher based on information provided from the consultations and workshops, interviews, and the surveys in Appendices 4 to 6. For each strategic pathway, the table columns, and the reasoning for their choice, are as follow:

- **Key Elements** – These are the 4 key elements of the Strategic Pathway and form the components for developing a strategy for the themes of actions to be identified in each table. The key elements provide the prompts for the possible actions to be considered;
- **Current Situation and Challenges** – This information is derived from the information in the appendices and information gathered from interviews, and during the consultations and workshops. This reflects the assessment of needs;
- **Desired Future** – The statements in this column reflect the goals that are to be achieved and are aligned to the strategic pathway generally, and the current situation specifically;
- **Estimated Capacity Gap** – These are the ‘gaps’ in current capacity and capability that will need to be addressed in the implementation phases of the IGIF; and
- **Possible Actions** – This is a list of actions to be considered in the implementation of the IGIF in order to overcome the gaps in current capability, and to achieve the desired future state.

8.4.2.2 Data Collection: Results

The Needs Assessment and Gap Analysis results for EGII and Ethiopia are provided in Tables 8.1 to 8.9. These are summarised results of the issues, current situation, challenges, gaps, possible actions, and objectives. Numerous insights and actions are borne out of the application of the IGIF to this process. For example, 24 immediate actions arise from the nine tables. But what does this mean? The challenge then becomes, how to organise mechanisms to follow-up on these actions and take next steps, and then determine who needs to take steps to implement the action, how, and with what resources? It is also highly likely that the available resource capabilities and capacities will require the actions to be prioritised. The structure of the strategic pathways and their key elements will assist in the prioritisation process. In other words, it is about taking the next strategic steps towards the sustainable adoption of the derived actions so as to achieve the goals and objectives identified.

As mentioned in Chapter 7 (Section 7.3.6), step-by-step actions for how each of the strategic pathways and their key elements, and by extension the results of the Needs Assessment and Gap Analysis, are operationalised within a country are not described, and are beyond the aims and objectives of this dissertation. The IGIF Implementation Guide will provide the guidance and options on actions to be taken for each of the nine strategic pathways within countries. However, a preliminary high-level strategic overview of how the IGIF contributes to achieving actionable options and outcomes for Ethiopia, can be demonstrated through the use of the key elements of the strategic pathways as summarised in Chapter 7, Section 7.3.6. These are presented (Box 8.1 to Box 8.9) below.

Table 8.1: Strategic Pathway 1 – Governance and Institutions

Key Elements Providing Strategic Guidance	Current Situation and Challenges From Workshops, Interviews and Appendices 4-6	Desired Future State Goals and Objectives	Estimated Capacity Gap For Implementation	Possible Actions Actions to be Considered
Governance Model Leadership Institutional Arrangements Value Proposition	EGII is mandated to coordinate national geospatial information management. National spatial information and technology policy, and national open data policy is enacted. Governance arrangements are in place, but the required implementation plans are not. The existing policy frameworks lack alignment and are not implemented. Also a lack of awareness, political will, and awareness on the policy frameworks throughout the geospatial industry. Lack of culture in coordination and cooperation across institutions. Still fragmented and/or siloes in institutions. There is an initial strategy on the role of geospatial information, which can be built upon to strengthen geospatial information management. But there is still a lack of understanding about the value of geospatial information. There is a weak link or communication gap between the political/policy level and the geospatial information expertise. Initiatives have been initiated to address SDGs from some government organisations, but not enough.	Goal 1: Effective Geospatial Information Management. Goal 2: Increased Capacity, Capability and Knowledge Transfer Goal 3: Integrated Geospatial Information Systems and Services. Goal 4: Economic Return on Investment. Goal 7: Enhanced National Engagement and Communication. Goal 8: Enriched Societal Value and Benefits. Enabling geospatial information governance, policy and institutional arrangements. Establishing governance arrangements to bring together institutions to share and provide access to data is the most fundamental initiative, and must be given the highest priority.	Urgent need to determine the best approach for championing the importance of geospatial information. For example, through an Executive Order or sponsored legislation. There are requirements for a central hub or governance mechanism (such as a Governing Board) for the coordination of geospatial information management that facilitates cross-agency coordination and cooperation. Governance (institutions, policies and laws) are not enforced to be implemented, or there is no system to implement and monitor them. The availability of a number of policies and laws should be seen as an advantage to leverage. There is a need for a strategy to deliver the leadership, roles and responsibilities, and guidance for integrated geospatial information management across all levels of government.	Establish leadership, governance models, institutional arrangements and a clear value proposition as a means to strengthen participation and commitment. Attain political endorsement, trust, strengthen institutional mandates, and build a cooperative data sharing environment through a shared understanding of the value proposition of geospatial information. Immediate actions may include: • Appoint a Governing Board. • Establish a Geospatial Coordination Unit and Specialist Working Groups. • Develop/complete a Geospatial Strategy. • Implement a Governance Model. • Develop a Value Proposition Statement. • Implement a Reporting Framework.

Table 8.2: Strategic Pathway 2 – Policy and Legal

Key Elements Providing Strategic Guidance	Current Situation and Challenges From Workshops, Interviews and Appendices 4-6	Desired Future State Goals and Objectives	Estimated Capacity Gap For Implementation	Possible Actions Actions to be Considered
Legislation Policies, Norms and Guides Data Protection, Licensing and Sharing Responsibility and Accountability	No legislation or system to implement geospatial policies and laws. No mandated policy for data sharing, and no initiatives on awareness creation of these benefits. Existing policy frameworks lack alignment and are not yet implemented. No strategy on the role of data exchange, licensing and sharing. There is no data sharing culture, which has led to the low level of geospatial information and technology usage. Geospatial information is not accessible. Information sharing processes are flimsy and ad hoc.	Goal 1: Effective Geospatial Information Management. Goal 3: Integrated Geospatial Information Systems and Services. Goal 4: Economic Return on Investment. Goal 7: 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 is key. Can be solved easily once all governance arrangements and policy frameworks are in place.	Need to communicate and ensure the understanding of legal and policy language, especially the benefits for data licensing and sharing. Privacy and security of sensitive data are concerns that need to be addressed and managed. Sharing data across agencies and institutions is critical. How do we foster this with those who do not wish to share data? Governance (institutions, policies and laws) are not enforced to be implemented, or there is no system to implement and monitor them. The availability of a number of policies and laws should be seen as an advantage to leverage.	Establish a robust policy and legal framework that is essential for instituting effective and efficient national geospatial information legislation and policy. Enable/ensure the availability, accessibility, exchange, application and management of geospatial information. Proactively monitor the policy and legal environment, particularly with regard to designating the official responsibility for the production of data. Immediate actions may include: • Establishing an independent geospatial policy and legal review group. • Review and assess the environment within which the policies and laws will operate in government.

Table 8.3: Strategic Pathway 3 – Financial

Key Elements Providing Strategic Guidance	Current Situation and Challenges From Workshops, Interviews and Appendices 4-6	Desired Future State Goals and Objectives	Estimated Capacity Gap For Implementation	Possible Actions Actions to be Considered
Business Model Investment Opportunities Benefits Realisation	Insufficient government funding. No one is contributing to enhance national government data sources. There is no study that shows the economic return on investment for geospatial. There is no formal study or report to indicate the evolution of new business ventures as a consequence of geospatial data access. Data is being used in land administration, infrastructure development, and natural resource management. Coverage of the economic sectors is limited. In terms of benefits, the country at large is still at the beginning stage of geospatial information usage for planning and decision making. Urban planning and infrastructure development are not as such based on spatial analysis and spatial planning.	Goal 1: Effective Geospatial Information Management. Goal 3: Integrated Geospatial Information Systems and Services. Goal 4: Economic Return on Investment. Goal 7: Enhanced National Engagement and Communication. Goal 8: Enriched Societal Value and Benefits. Return on economic investment shall be studied together with the return on investment assessment. The economic return on investment shall be assessed at least every two years. Decisions in areas of utility, services, urban planning and management must be made using geospatial information.	Needs further structured discussions on supporting evidence and information about financial issues in Ethiopia. There are some initiatives to develop public-private partnerships by Ministry of Finance and Economy. Need to understand the implementation costs and ongoing financial commitment necessary to deliver the national geospatial information program. Appropriate investment in all strategic pathways will be paramount for long-term sustainability. Data and infrastructure will be critical.	Establish the required business model, develop financial partnerships, and identify the investment needs and means of financing, including funding sources, for the implementation of the Strategic Framework Capture the benefits realisation milestones that will need to be achieved to maintain momentum. Continuous promotion and awareness creation initiatives must be undertaken Return on economic investment needs to be studied together with the return on investment assessment. Immediate actions may include: Establishing a financial management function within the governance framework to manage all actions under the Financial Strategic Pathway.

Table 8.4: Strategic Pathway 4 – Data

Key Elements Providing Strategic Guidance	Current Situation and Challenges From Workshops, Interviews and Appendices 4-6	Desired Future State Goals and Objectives	Estimated Capacity Gap For Implementation	Possible Actions Actions to be Considered
Data Themes Data Supply Chains Custodianship, Acquisition and Management Data Curation and Delivery	Available data is difficult to access as it is found in the hands of individuals, as there are very few, if any, central repositories in most organisations. Data is available in organisational silos, and almost all the data suffers from the lack of metadata. There is fear in data security issues. This goes against sharing data more openly. No one is contributing to enhance and build national government data sources. There is no suitable condition for individuals or groups to contribute to national data sources. The majority of data available in organisational silos contains only basic attributes to make base maps and thematic maps. The national datasets lack the necessary diversity to analyse complex relationships. Poor understanding of the economic benefit of using geospatial information, unknown return on investment of geospatial initiatives, poor insight on the potential usage, and data duplication.	Goal 1: Effective Geospatial Information Management. Goal 3: Integrated Geospatial Information Systems and Services. Goal 4: Economic Return on Investment. Goal 7: Enhanced National Engagement and Communication. Goal 8: Enriched Societal Value and Benefits. Challenges can be solved once all of the governance arrangements, policy frameworks, metadata, and content standards are in place. Can be possible when national repositories are defined and put in place and awareness is created. Data must be made easily accessible via a single central hub. Expansion of geospatial technology suppliers.	There were debates on organisation's roles and responsibility problems i.e data redundancy not clear. There were debates on organisation's custodianship due to duplication of data produced. Developing integrated geospatial information management and sharing frameworks is believed to solve the situation. Recognised that data completeness (coverage and characteristics) are concerns, related to data quality and the accuracy of that data. Integration of SDG performance statistics and geospatial information must be given high priority as the spatial extent/coverage of achievement is depicted better using thematic maps.	Establish a geospatial data framework and custodianship guidelines for good practice collection and management of integrated geospatial information (accurate, logical, consistent, standardised and interoperable) that is appropriate for cross-sector and multi-disciplinary use. Enable data custodians to meet their data management, sharing and reuse obligations to government and the user community. Develop data supply chains for organising, planning, acquiring, integrating, managing, maintaining, curating, publishing and archiving geospatial information. Immediate actions may include: Implement a data framework, inventory and then data theme road map for coordinating cross-government activities.

Table 8.5: Strategic Pathway 5 – Standards

Key Elements Providing Strategic Guidance	Current Situation and Challenges From Workshops, Interviews and Appendices 4-6	Desired Future State Goals and Objectives	Estimated Capacity Gap For Implementation	Possible Actions Actions to be Considered
Quality Technology and Data Interoperability Community of Practice Compliance	GII accepts ISO standards in the geospatial sector, but it is more conceptualised than actually being implemented. The ISO standards need to be amended based on our geospatial sector needs. But they are used as a reference in a fragmented way in different organisations. Even if we have ISO standards for purchasing software and services, we don't yet use the standards as required. There is a community of practice with standards. Some standards are difficult to understand and know when and how to apply them in Ethiopia and an African context. The use of standards and adherence to metadata are both weak. No national standards in place for geospatial data, metadata and services.	Goal 1: Effective Geospatial Information Management. Goal 2: Increased Capacity, Capability and Knowledge Transfer. Goal 3: Integrated Geospatial Information Systems and Services. Goal 5: Sustainable Education and Training Programs. Goal 7: Enhanced National Engagement and Communication. Objective is to be able understand and apply the standards available. This is not easy for African countries. How the standards are used and their benefits need to be better communicated.	National success in standards requires an efficient governance model, inclusive of relevant stakeholders, and a commitment to assess, establish, and maintain a common standards framework. There were debates on availability of standards. We know that some standards are available unofficially. So, it is difficult to mention their name and to acknowledge their availability. The importance of 'consistency' of standards and their use is very essential to be mentioned.	Establish and ensure the adoption of best practice standards and compliance mechanisms that enable data and technology interoperability, which are fundamental to delivering integrated geospatial information. Enable different information systems to communicate and exchange data through internationally agreed standards and interoperability. Immediate actions may include: • Establish a process to review, assess, develop, evaluate, and endorse national standards for geospatial information management. These would be based on International Standards. • Raise awareness of the benefits of moving towards a standards-based approach for geospatial data management.

Table 8.6: Strategic Pathway 6 – Innovation

Key Elements Providing Strategic Guidance	Current Situation and Challenges From Workshops, Interviews and Appendices 4-6	Desired Future State Goals and Objectives	Estimated Capacity Gap For Implementation	Possible Actions Actions to be Considered
Technological Advances Innovation and Creativity Process Improvement Bridging the Geospatial Digital Divide	Innovation in the area if geospatial technology is at its lower stage in the country. Only minimal technology platforms are in place for information sharing. Initiatives are underway to establish technology incubation networks. National innovation strategy is in place. National digital industry policy is in place. Private and public sector institutions are starting to use online platforms and advanced techniques to develop solutions. Education and research institutions are providing BSc. and MSc. level degrees in the fields of geospatial sciences. The dynamic nature of technology change and innovation is difficult to keep up with. Many organisations have prevailing outdated technologies, which is combined with a lack of technology access/incentive, due to available funding. Lack of research in geospatial technologies and innovation. Often poor internet connectivity.	Goal 1: Effective Geospatial Information Management. Goal 2: Increased Capacity, Capability and Knowledge Transfer. Goal 3: Integrated Geospatial Information Systems and Services. Goal 4: Economic Return on Investment. Goal 5: Sustainable Education and Training Programs. It is important to focus on the establishment of geospatial technology centres of excellence and innovation networks. The curriculum in universities and training institutions needs to be updated regularly to fit the fast changing technology and innovation spectrum. Need to bridge the ICT and geospatial digital divide.	There were debates on availability of ICT infrastructure that can be used for sharing geospatial information. Need to stimulate the use and development of the latest cost-effective technologies, process improvements and innovations so that real and positive change can be made and sustained. Need to evaluate how the Ethiopian NSDI and other data portals are able to be integrated, and for more 'online' services and 'enterprise' data can become available. Even though innovation has the potential to have a significant impact on stimulating and embracing rapid change and to bridge the geospatial digital divide, there is a general lack of capacity to do so without considerable industry support.	Create enhanced opportunities for innovation and creativity as technology and digital transformation continues to evolve. Innovation has the potential to have the most significant impact in stimulating and triggering rapid change, being able to leapfrog outdated technologies, and being able to be more agile in efforts to bridge the geospatial digital divide. Stimulate the use of the latest cost-effective technologies, innovations and process improvements. Immediate actions may include: • Leveraging the geospatial aspects of the National Innovation Strategy. • Identifying technology needs through a needs assessment. • Looking at ways to federate data and systems across the various data portals.

Table 8.7: Strategic Pathway 7 – Partnerships

Key Elements Providing Strategic Guidance	Current Situation and Challenges From Workshops, Interviews and Appendices 4-6	Desired Future State Goals and Objectives	Estimated Capacity Gap For Implementation	Possible Actions Actions to be Considered
Cross-sector and Interdisciplinary Cooperation Community Participation Industry Partnerships and Joint Ventures International Collaboration	There is no formal study or report to indicate the evolution of new business ventures as a consequence of geospatial data access. There are some bi-lateral cooperation arrangements for specific areas in geospatial information. There is only limited multi-lateral cooperation. We lack national geospatial information management frameworks to support international cooperation and partnerships. We have been working and continue to work with international partners in areas of land management. There are no strategic partnerships. Rather we have operational partnership/project based partnerships. We need to include the contribution of policy-makers as part of partnerships in the hierarchical order – as they influence what we can do, and who with.	Goal 2: Increased Capacity, Capability and Knowledge Transfer. Goal 4: Economic Return on Investment. Goal 6: International Cooperation and Partnerships. Goal 7: Enhanced National Engagement and Communication. Goal 8: Enriched Societal Value and Benefits. Partnerships bring diversity that can increase organisational knowledge, create capacity and develop capabilities.	Working with more partners would help but the most important thing is developing national capability first and foremost. Developing internationally compatible geospatial information management frameworks is utmost urgency. Always be on the lookout for potential strategic partners. Some may be international partners, while others may be local. We, as all African countries, are dependent on partnerships and international collaboration to assist with funding and capacity support for much of our new and innovative work.	Partnerships, joint ventures, and international cooperation bring together different strengths and perspectives that stimulate creativity and innovation, often through unique capabilities, and drive achievements towards common goals. Establish cross-sector and interdisciplinary cooperation and collaboration with all levels of government and the geospatial industry. Immediate actions may include: • A needs assessment and gap analysis will provide a starting point for understanding areas needed to be strengthened, and what partners are able to support. • Identifying and selecting potential partners, and the associated arrangements.

Table 8.8: Strategic Pathway 8 – Education and Capacity

Key Elements Providing Strategic Guidance	Current Situation and Challenges From Workshops, Interviews and Appendices 4-6	Desired Future State Goals and Objectives	Estimated Capacity Gap For Implementation	Possible Actions Actions to be Considered
Formal Education Awareness Raising Professional Workplace Training Entrepreneurship	Private and public sector institutions are starting to use online platforms and advanced techniques to develop education solutions. Education and research institutions are providing BSc. and MSc. level degrees in the fields of geospatial sciences. The education in Universities lacks regular reviews and updates. Most of the courses focus on theories with little focus on skills. The common fields of study include GIS and Remote Sensing, Surveying, Geomatics Engineering and Geo-informatics. There are new initiatives in capacity and education, but they are not strategic. Rather they are only operational. Government sees higher education as an important plank in its strategy for social and economic development. Contributes to national development. Expansion of higher education is a considerable investment, both financially and politically. Not enough institutions.	Goal 2: Increased Capacity, Capability and Knowledge Transfer. Goal 5: Sustainable Education and Training Programs. Goal 6: International Cooperation and Partnerships. Goal 7: Enhanced National Engagement and Communication. Goal 8: Enriched Societal Value and Benefits. The curriculum in Universities and training institutions should be updated regularly to fit the fast changing technology spectrum and methods. A regular syllabus update is necessary.	An education and capacity challenge for many developing countries is the increasing divide in data and technology. By introducing a change in the operations and practice of the principles and values of education and capacity development for governments and the geospatial industry, a paradigm shift in the requisite skills base can be made. Investing in technical and tertiary education has significant positive impact on national capacities, including ICT and geospatial information. Universities and the curriculum need to be modernised.	Establish enduring education systems and capacity-building programs so that geospatial information management and entrepreneurship can be sustained in the longer-term. Education and capacity are integral for transforming the use of geospatial information and increasing its adoption and innovative potential across a broader range of stakeholders. Immediate actions may include: • Working with Universities, establish an Education and Capacity Working Group to assess, analyse, design and develop an education strategy for the geospatial sciences. • Develop an inventory to establish a baseline (current situation) of current educational knowledge, skills and resources. • Consider outreach and engagement with community and VGI mapping initiatives.

Table 8.9: Strategic Pathway 9 – Communication and Engagement

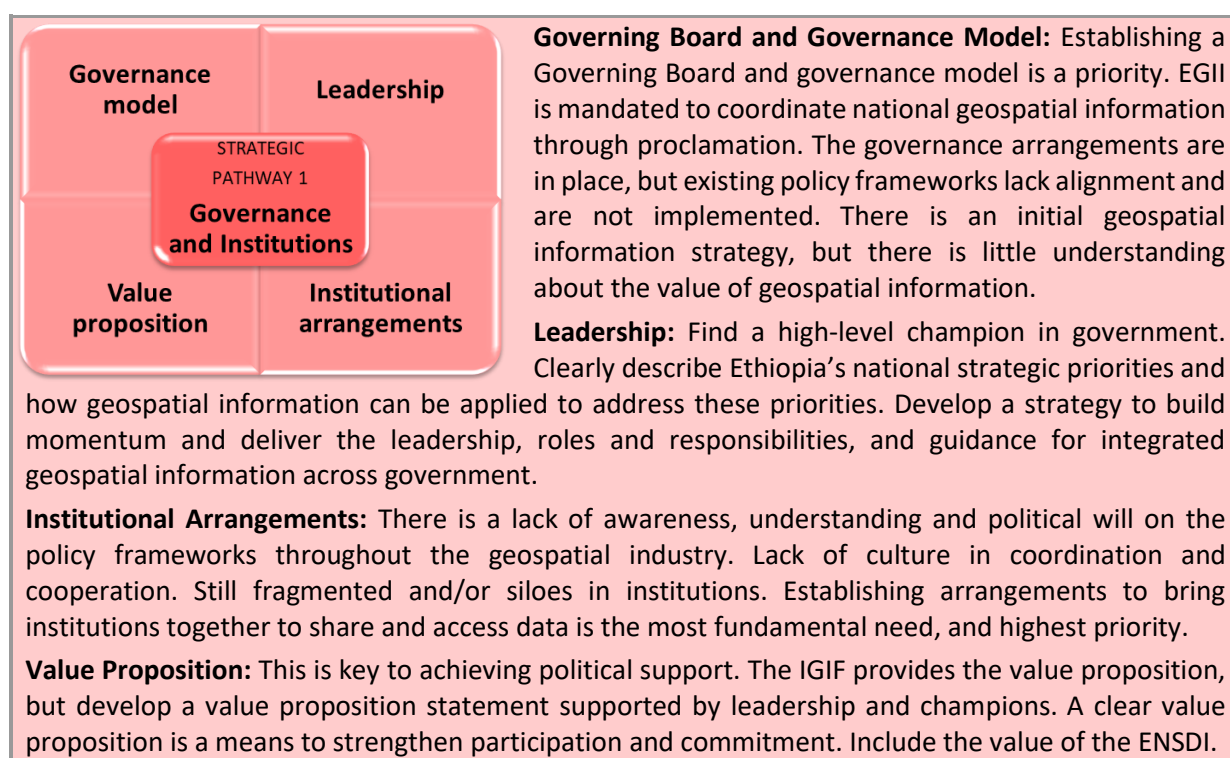
Key Elements Providing Strategic Guidance	Current Situation and Challenges From Workshops, Interviews and Appendices 4-6	Desired Future State Goals and Objectives	Estimated Capacity Gap For Implementation	Possible Actions Actions to be Considered
Stakeholder and User Engagement Strategic Messaging and Engagement Communication Strategy, Plans and Methods Monitoring and Evaluation	There is no National Geospatial Strategy or equivalent due to: • Poor attention from the concerned stakeholders; • Poor political will and lack of awareness from higher officials; and • Lack of commitment from concerned institutions. There has not been any promotions from the government regarding the use and value of geospatial information that we can recall. Most government organisations do not even consider to include geospatial information in their decision-making processes. GII has been recognised with a global award at Geospatial World Forum for its services. Redundancy in strategic mandate is limited, and there is poor awareness and supporting strategies. There is an engagement strategy in the major governmental organisations working in geospatial area to create awareness in the value of geospatial information.	Goal 1: Effective Geospatial Information Management. Goal 2: Increased Capacity, Capability and Knowledge Transfer. Goal 3: Integrated Geospatial Information Systems and Services. Goal 6: International Cooperation and Partnerships. Goal 7: Enhanced National Engagement and Communication. Goal 8: Enriched Societal Value and Benefits. Government officials at the highest levels must advocate the value of geospatial information to the overall economic development of the nation. Advancing our national capabilities is very important. We need 'buy in' from key stakeholders.	Communication and engagement raises awareness and advocacy to politicians, decision-makers, business professionals, and the community of the relevance, and benefits of geospatial information at all levels. It does so in the midst of rapidly changing societal norms and economic outlooks, and against a backdrop of many competing national agendas and priorities. Strategic support should be a national priority. This is a 'must have' for the advancement of the industry. Commitment, collaboration, cooperation and communication are essential.	Stakeholder identification, user engagement and strategic communication are essential to successfully develop productive and enduring relationships, and deliver and sustain a national geospatial information program. It is important to identify these stakeholders and users and analyse their level of interest, expectations, importance and influence. Immediate actions may include: • Developing a communication and engagement strategy will guide an entire program and set the messaging tone and directions for the organisation. • Consider a national geospatial branding strategy for GII. • Develop key messages that support national geospatial and related policies. • Communicate the value and benefits of geospatial information to government.

Given this overview and solutions-orientated approach, EGII has further concluded that its vision and mission are as follows:

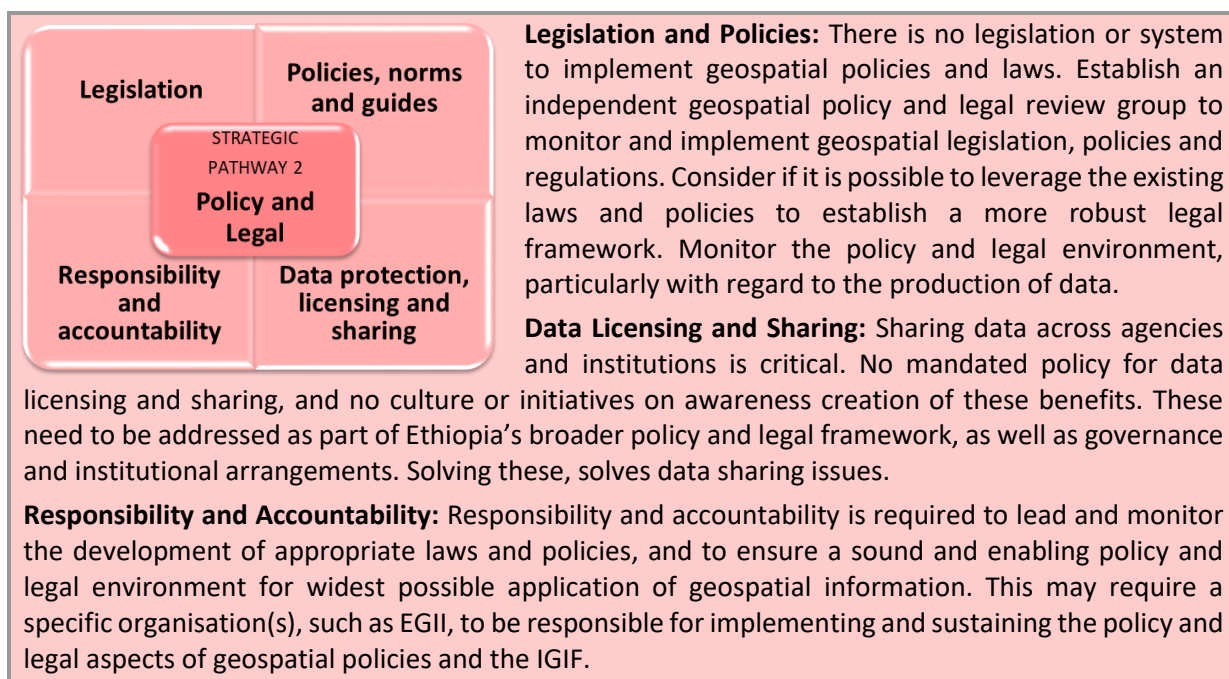
EGII VISION <i>Ensure the integrated management of geospatially referenced information that responds to decision making, sustainable socio-economic development and environmental management.</i> EGII MISSION <i>Build cross-sectorial integration that enhances efficient production and sharing of demand-driven geospatially referenced information in order to drive evidence-based decision making processes, innovation, social services, and business, social and economic development.</i>

While all eight Goals of the IGIF have applied to the strategic pathways, as illustrated in Tables 8.1 to 8.9, EGII has additionally identified three of its own unique National Priority Goals:

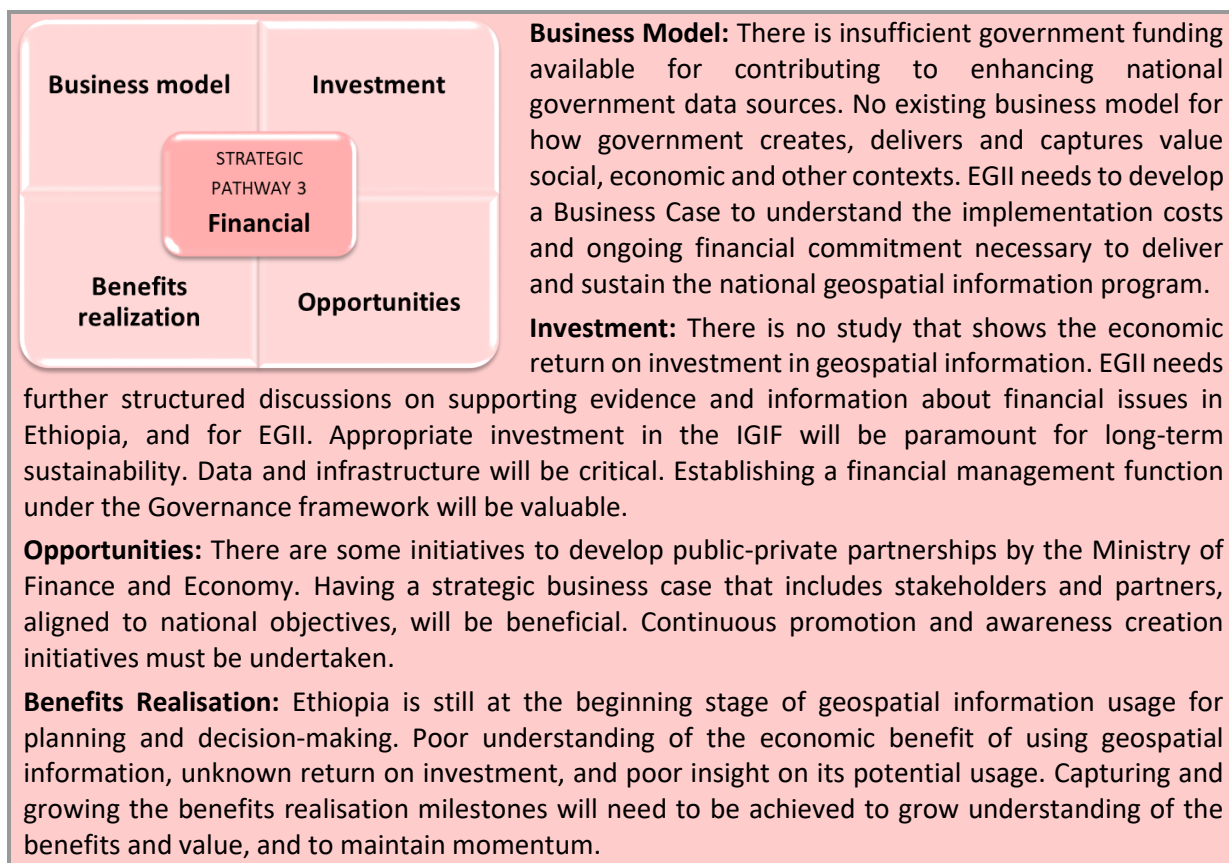
EGII NATIONAL PRIORITY GOALS (FUTURE STATE)	1. Establish proper institutional arrangements, and legal and policy framework in order to strengthen coordination and cooperation among stakeholders. 2. Implement standards for the Ethiopian National Spatial Data Infrastructure (ENSDI) in order to enable efficient sharing and utilisation of geospatial-based information across multiple sectors and line Ministries. 3. Enhance the application of geospatially referenced information through innovative research in order to achieve national sustainable development goals (SDGs).



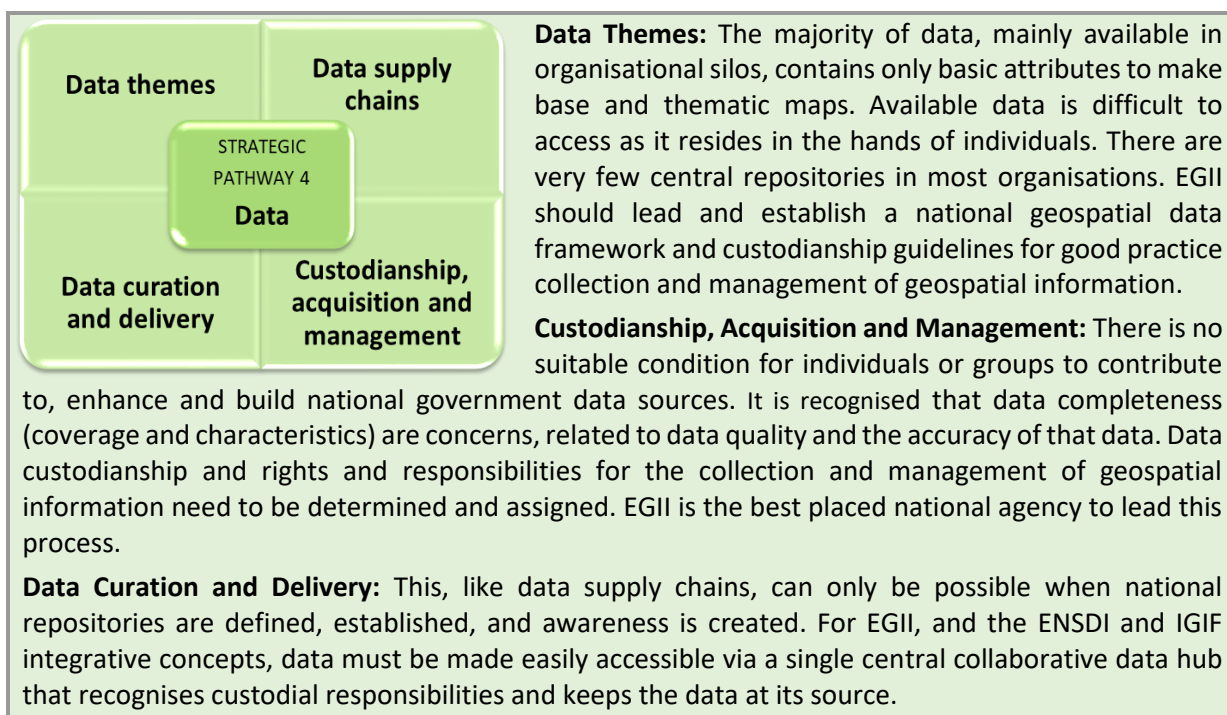
Box 8.1: Strategic Pathway 1: Governance and Institutions – actionable options for EGII to implement the IGIF.



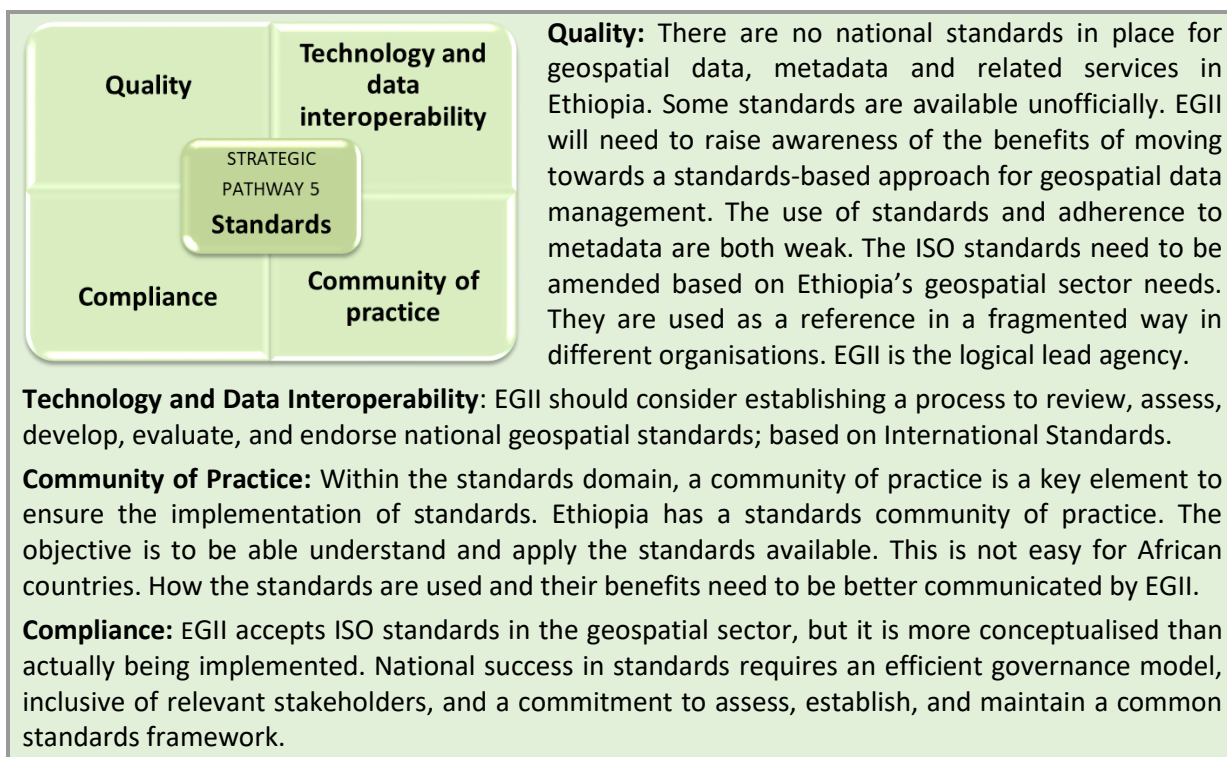
Box 8.2: Strategic Pathway 2: Policy and Legal – actionable options for EGII to implement the IGIF



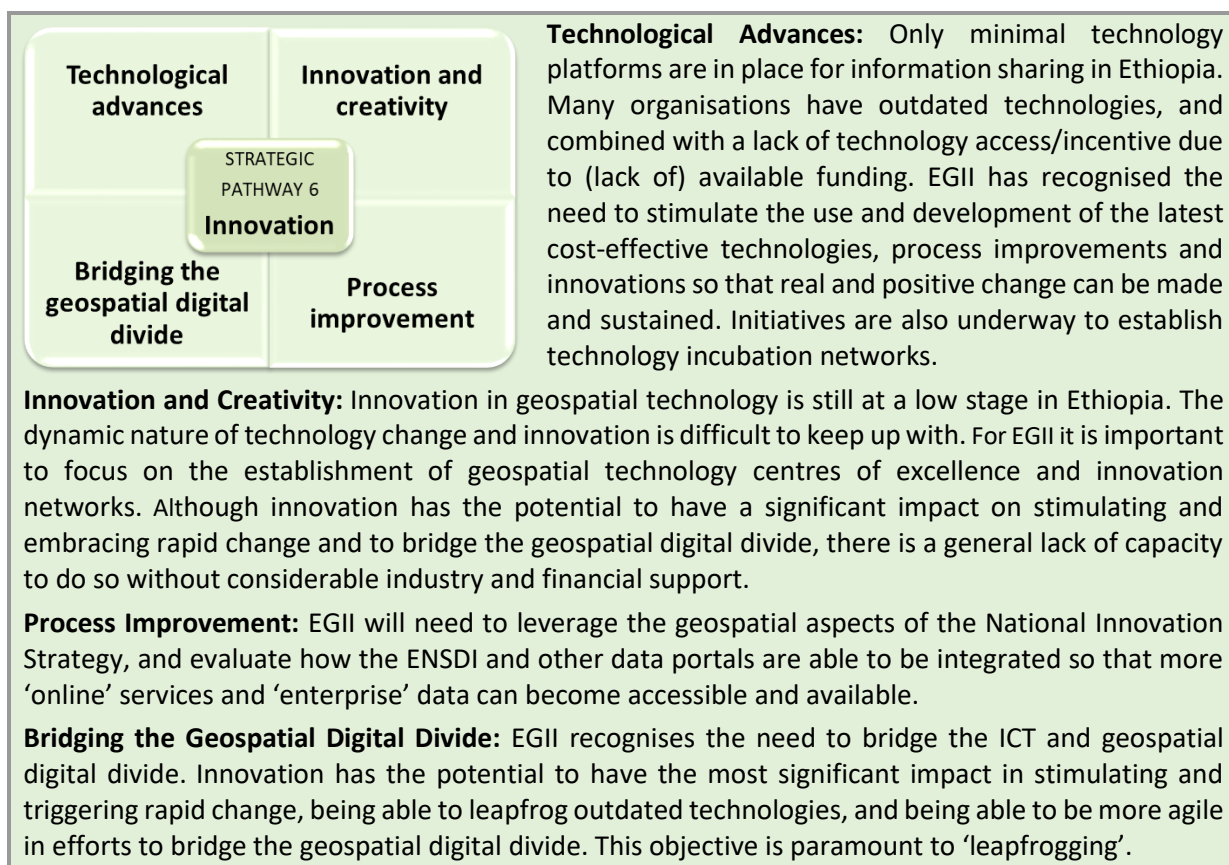
Box 8.3: Strategic Pathway 3: Financial – actionable options for EGII to implement the IGIF.



Box 8.4: Strategic Pathway 4: Data – actionable options for EGII to implement the IGIF.



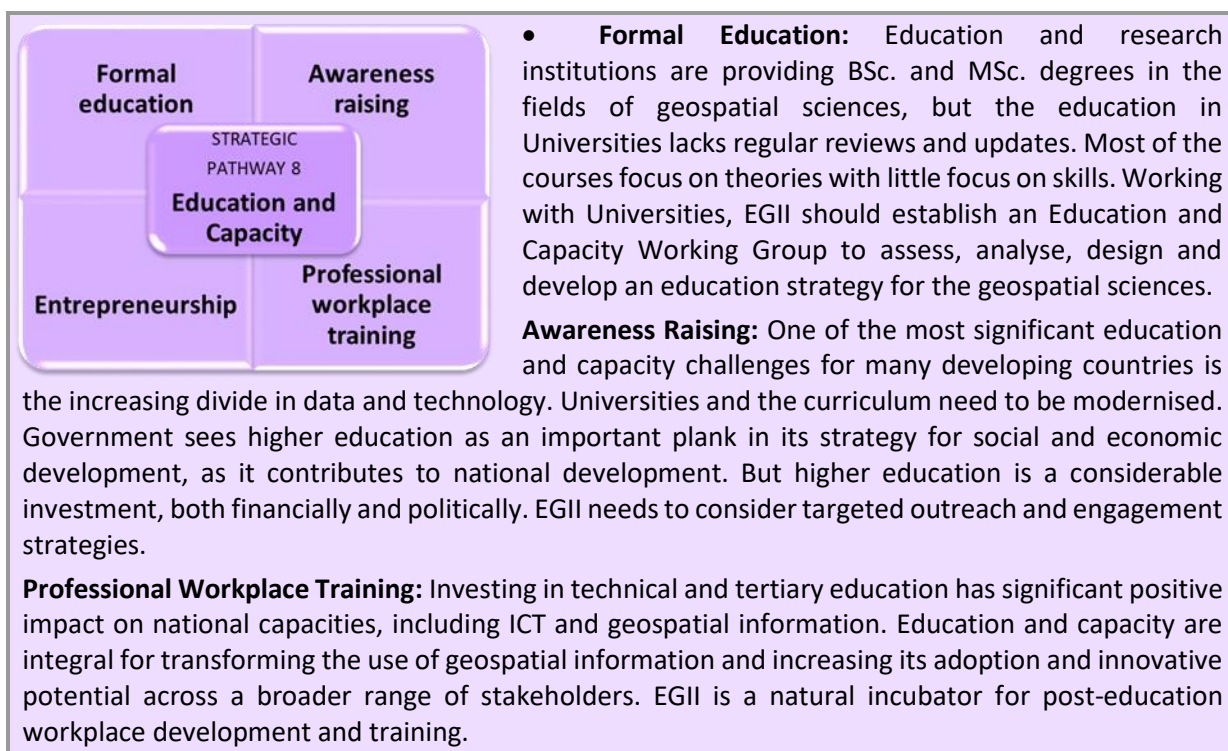
Box 8.5: Strategic Pathway 5: Standards – actionable options for EGII to implement the IGIF.



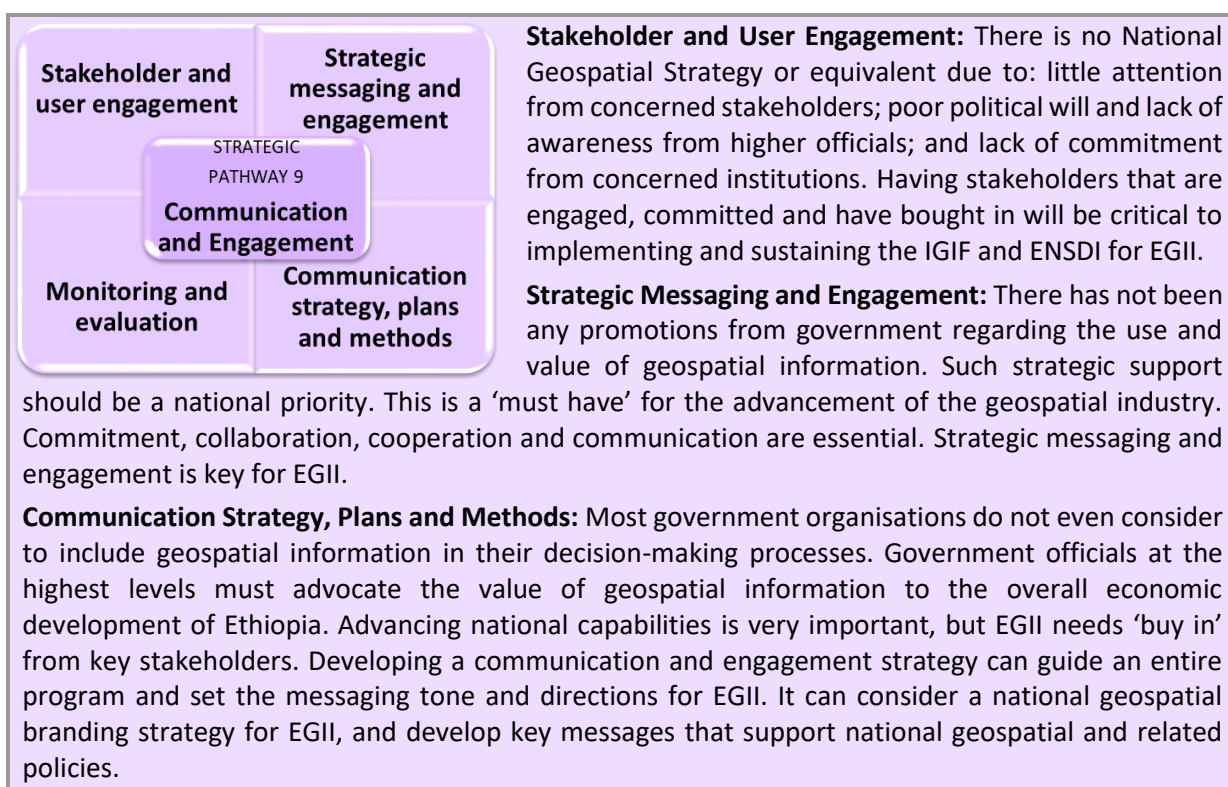
Box 8.6: Strategic Pathway 6: Innovation – actionable options for EGII to implement the IGIF.



Box 8.7: Strategic Pathway 7: Partnerships – actionable options for EGII to implement the IGIF.



Box 8.8: Strategic Pathway 8: Education and Capacity – actionable options for EGII to implement the IGIF.



Box 8.9: Strategic Pathway 9: Communication and Engagement – actionable options for EGII to implement the IGIF.

8.4.2.3 Outcomes of IGIF Assessment Trial

This dissertation focusses on Africa and Ethiopia as the first case study for the iterative development, testing and application of the IGIF. However, this case study and its results has catalysed a far wider, global reach. As discussed in Chapter 7 (Section 7.4, and portrayed in Figures 7.7 and 7.8) multiple regional consultation workshops and expert meetings have been convened since the adoption of the IGIF by UN-GGIM in August 2018. Organised and led by the researcher, as the UN-GGIM Secretariat, the workshops have rapidly communicated and grown the global understanding, awareness and relevance of the IGIF, receiving wide and unanimous acclaim for its substance and purpose, and even translated by countries into multiple languages (UN-GGIM, 2019d). These workshops were made possible (funding participants from developing countries) as a result of a successful bid by the researcher under the 2030 Agenda for Sustainable Development Sub-fund of the United Nations Peace and Development Trust Fund,²⁹ and implemented during the period from December 2018 to November 2019.

Further, the IGIF has been an anchor in global fora. Ministers specifically referenced the IGIF in their interventions during the Ministerial Segment of the first World Geospatial Information Congress, convened in Deqing, China in November 2018.³⁰ With more than 2000 participants in attendance, the Moganshan Declaration, ‘The Geospatial Way to a Better World’ issued at the conclusion of the World Congress, reflected this resolve to *“take up the challenge by Ministers and other high-level decision-makers to ensure that geospatial information and location enablement is able to be recognised and underpin the SDGs at national levels through the Integrated Geospatial Information Framework as a fundamental and enabling methodological framework and infrastructure for creating greater social, economic and environmental understanding, evidenced based decision making, design and delivery of projects and services, and implementing and achieving the 2030 Agenda for Sustainable Development”* (WGIC, 2018, p. 2). More specifically with regard to bridging the geospatial digital divide through geospatial technology and innovation, participants *“affirm that geospatial technologies and innovation have been unequally adopted, and that there is an urgent need to effectively bridge the geospatial digital divide to achieve ‘digital transformation’, to democratise and transfer these technologies and associated data through the enabling global mechanism of the 2030 Agenda and Integrated Geospatial Information Framework, noting that innovative technologies such as the cloud, big geospatial data analytics, machine learning, geospatial knowledge services and integrated information systems can ensure such capabilities are easily reachable and useable by developing countries”* (WGIC, 2018, p. 2). This created considerable momentum for the IGIF and the proposed workshops leading into 2019.

²⁹ <https://www.un.org/en/unpdf/sdg-2018-05.shtml>

³⁰ <http://ggim.un.org/unwgic/>

The IGIF underpins the 11th Tranche (2018-2021) of the United Nations Development Account Project (Appendix 3), which focusses on improving and strengthening national geospatial information management and capacities in six target developing countries; Burkina Faso, Ethiopia, Fiji, Mongolia, Nepal and the Kingdom of Tonga. This Project now provides guidance and resources for the implementation of the IGIF in these countries by 2021.

The IGIF is also being adopted or implemented at various levels by a growing number of countries around the world, including some of the most developed countries – Ireland³¹ and Australia³² being examples. Guyana³⁴ was one of the very first countries to implement the IGIF. Others now include Colombia, the Dominican Republic, Georgia, Kyrgyzstan, Macedonia, Malawi, Moldova, Nicaragua, Norway, the Philippines, Serbia, Seychelles, Sweden, Tajikistan, Ukraine, and Vietnam.³⁵

The IGIF, its vision, mission, underpinning principles, goals and strategic pathways, have been developed, tested and applied to numerous national geospatial situations and circumstances. This is proof that the IGIF is robust and has achieved the requirements of the research aim and objectives.

8.5 Chapter Summary

This Chapter illustrated the IGIF's relevance, flexibility and applicability to be synthesised, implemented and prototyped via a two-dimensional case study – regionally within the continent of Africa, and nationally within the country of Ethiopia. The case study choice, although fraught with challenges that would not exist in more developed regions (economy and advanced technological infrastructure), ensured that the perspectives of the least developed region on Earth could be captured. The voice of Africa was able to be heard and acknowledged, enabling the IGIF to be iteratively tested and evaluated against the region's expert thinking and understanding, along with other, more developed, regions of the world as briefly mentioned in the previous section. Based on feedback from each of the consultation workshops, the researcher was able to develop the next iteration for review and enhancement.

In this case study, acceptance of the IGIF and its considered usability by a 'broader' and 'targeted' test audience provided the evidence and criteria for what makes a good and implementable Framework. The case study demonstrated how geospatial information can be integrated into national sustainable development policies and strategies. It also considered the role of the NSDI, regionally and nationally, as the national geospatial information system of the sustainable development data flow

³¹ https://www.osi.ie/wp-content/uploads/2019/03/Osi-Strategy-2019-2021_eng_small.pdf

³² https://nginx-anzlic-master.govcms.amazee.io/sites/default/files/files/ANZLIC%20Strategic%20Plan%202020-24_3.pdf

³³ <http://locationindex.org/home.html>

³⁴ <https://www.cepal.org/sites/default/files/presentations/igif-implementation-in-guyana-glsc.pdf>

³⁵ A number of country examples were presented at the International Workshop and Seminar in Deqing, China, from 17-22 October 2019. <http://ggim.un.org/meetings/2019/Deqing/>

framework, as a means to provide reliable fundamental geospatial data, and to provide both the enabling platform and connection point to other national information systems, and to the SDGs.

The next Chapter, as the concluding Chapter of this dissertation, presents the achievements and findings of this research, conclusions, and also the future research directions in this field.

Chapter 9: Conclusions and Future Directions

9.1 Introduction

This concluding chapter re-examines the research objectives and considers the outcomes achieved in this research. The significance of the research work to theory and practice is highlighted, the original research problem is reflected upon, and provides a platform for presenting an outlook for the future, including potential areas for further research.

9.2 Addressing the Research Problem

The main aim of this research, as set out in Chapter 1 was to:

Define, develop, test and apply a new national strategic geospatial information framework to enable countries to integrate geospatial information into national sustainable development strategies and processes, with particular application to the SDGs, so that they will be better able to measure and monitor progress and transformative change within their individual national circumstances, and mainstream evidence-based policy-setting and decision-making to achieve sustainable development.

In response to this aim, Chapter 7 iteratively designed and developed a National Strategic Geospatial Information Framework that provides the roadmap for countries, especially developing countries, to strengthen their national geospatial arrangements to better measure and monitor the SDGs within their national circumstances and arrangements. The development of the Framework was informed by the issues identified in the literature review in Chapters 2 and 3, the implications of the geospatial digital divide in Chapter 5, and the integrated geospatial information systems framework inputs in Chapters 6. In this process, the value and significance of the Strategic Framework was quickly recognised by the national geospatial information experts within UN-GGIM, and adopted as the United Nations Integrated Geospatial Information Framework (IGIF) by the Member States of the United Nations. This provides overwhelmingly positive feedback and validation.

As presented in Chapter 8, the IGIF was tested and applied via a two-dimensional case study – regionally within the continent of Africa, and nationally within the country of Ethiopia. Both case studies undertaken as part of this research were designed specifically to meet this research aim. The first component was met through ‘test and validation’ with African countries in four consultative workshop settings convened at regular intervals from April 2018 to November 2019. The second component of the aim was met through the application of the IGIF in Ethiopia, through the Ethiopian Geospatial Information Institute.

The viability and effectiveness of the IGIF as a strategic framework has now been demonstrated through its adoption by all Member States of the United Nations and staged implementations, within a diverse range of national settings and circumstances, in more than 25 countries around the world.

The success of the research in meeting its aim is also based on the sequential process of meeting the research's six research objectives. These objectives were defined in Chapter 1 to be:

1. Examine and investigate existing concepts on sustainable development theory and practice, and review the relationships with and role of geospatial information.
2. Evaluate the evolution and development of geospatial information, its uptake at the intergovernmental level, applicability to the SDGs, existing mechanisms and initiatives; and identify issues and challenges impeding geospatial information from contributing more to sustainable development.
3. Investigate and evaluate the data flow – technology nexus, and the existence of the geospatial digital divide in developing countries.
4. Define and develop a conceptual national strategic geospatial information framework, with particular application to the geospatial requirements for measuring and monitoring the SDGs.
5. Demonstrate the utility and implementation of the national strategic geospatial information framework through a case study.
6. Evaluate the improvement of the framework and identify areas for future work and directions.

9.2.1 Research Objective 1

Examine and investigate existing concepts on sustainable development theory and practice, and review the relationships with and role of geospatial information.

Chapter 2 drew on literature from a range of sources, especially those from the United Nations, to provide the context for meeting this research objective. It was first necessary to provide an overview regarding the origins and evolution of sustainable development, emanating in the 1960s through growing environmental concerns. The Chapter then used the global United Nations conferences and processes, initiated in 1972, as the common anchor to demonstrate the mainstream theoretical framework and understanding of sustainable development. This included providing an enduring definition of sustainable development in 1987, determining the MDGs in 2000, the first global references to geospatial information in 2002, the subsequent touch points then growing relationship with geospatial information, and leading to the determination of the SDGs in 2015 – which anchored geospatial information into global sustainable development policy.

A review of the existing literature aided in the understanding of sustainable development, the ambiguities and trade-offs that come with it, and how it has evolved and been influenced over the past fifty years. A major gap that was identified in the literature was the lack of any real presence of cartography, national mapping or geospatial information, even though such concepts and enabling technologies were rapidly developing in parallel to sustainable development. This both suggested and confirmed a lack of understanding of these capabilities in sustainable development practices. The role of geospatial information, although very relevant to the social, economic and environmental issues being addressed, was almost invisible as a viable capability until 2002, and only then became prominent

in the Rio+20 outcome document, *The Future We Want*, in 2012 following the establishment of UN-GGIM in 2011, and its subsequent influence. Hence the importance of Research Objective 2.

Supported by a sustainable development timeline expanding more than half a century, the comprehensive review answered the first research objective.

9.2.2 Research Objective 2

Evaluate the evolution and development of geospatial information, its uptake at the intergovernmental level, applicability to the SDGs, existing mechanisms and initiatives; and identify issues and challenges impeding geospatial information from contributing more to sustainable development.

The second objective was met through the literature review in Chapter 3. For comparison and context with sustainable development in Research Objective 1, the Chapter first evaluated the five phases of geospatial information evolution from the early 1960s, in parallel to that for sustainable development. This captured the entire geospatial journey, from the pioneers through to today's digital transformation, and included the evolution of NSDIs, as national to regional information architectures. A key element was reviewing and documenting the history of cartography and geospatial information through the intergovernmental lens of the United Nations – which were initiated as regional processes by the United Nations in the late 1940s following the end of World War II. This history has never been recorded previously.

The Chapter describes the systemic problem with geospatial understanding and uptake at the policy level, and then focuses on the establishment of UN-GGIM, the contemporary role its global architecture plays in the global geospatial information landscape, and their applicability to the SDGs.

Like Chapter 2, a timeline, initiated in 1948, provides insights to the United Nations geospatial journey, which dramatically increased in visibility and relevance following the establishment of UN-GGIM in 2011. While the convergence and interactions between sustainable development and geospatial information initiatives have increased since that time, the literature review highlighted that they were not yet in as close a relationship as required. The lack of strategic frameworks or mechanisms for governments to determine how geospatial information can be implemented and integrated into sustainable development processes, especially at local and national levels, were still lacking.

9.2.3 Research Objective 3

Investigate and evaluate the data flow – technology nexus, and the existence of the geospatial digital divide in developing countries.

The third objective was met through the development of the frameworks in Chapters 5 and 6. Chapter 5 first reviewed the relevance of the digital divide in sustainable development processes, then concepts of the 'digital divide' itself, especially the relevance to Africa as the home of the majority of the LDCs, and as the implementation case study region for this dissertation. The Chapter then

introduced and described for the first time the ‘geospatial digital divide’ and the complex challenges that continue to exacerbate the ability for many developing countries to bridge this divide. The Chapter then discussed options for countries to close the gap in the geospatial digital divide, including to develop, strengthen and modernise their approaches to national mapping and geospatial information management through enabling technologies.

Chapter 6 addresses the data availability and integration issues for the 17 SDGs, 169 targets, and 232 global indicators. It designs and describes a conceptual integrated geospatial information systems framework as an integrative sustainable development ‘data flow’ that is anchored by the NSDI, and provides the underpinning building blocks and processes for countries to measure and monitor the SDGs with relevant and timely data. The Chapter highlights that sustainable data for sustainable development not only requires timely, accessible and reliable fundamental data across many disciplines and sectors, but an unprecedented amount of data on a wide variety of SDG topics, new and non-traditional sources of data, and the interoperable and integrated systems to harness the potential of the data. Meeting this objective was therefore a prerequisite requirement for Research Objective 4.

9.2.4 Research Objective 4

Define and develop a conceptual national strategic geospatial information framework, with particular application to the geospatial requirements for measuring and monitoring the SDGs.

The fourth objective was met through the iterative development and validation of the Strategic Framework in Chapter 7. This Chapter designed and described a National Strategic Geospatial Information Framework (Strategic Framework) to achieve the research aim. The Chapter first established six specific criteria to ensure the Framework’s success, the most important being that it must accommodate the needs of all countries – developed and developing – be flexible enough in its design to be able to be adapted and modified to individual jurisdictional needs, and able to be applied to the SDGs.

The Strategic Framework, informed by the previously described research objectives, was then developed as a conceptual prototype for further consultation and development with countries to gauge its applicability and usability. The first of the two-dimensional case studies (Chapter 8) then allowed the Framework to be iteratively developed and synthesised with experts in African countries over an 18 month period from April 2018 to November 2019.

During this process, the Strategic Framework was recognised by the United Nations and the World Bank as a means to progress an overarching geospatial framework to assist developing countries to bridge the geospatial digital divide. In August 2018, the Strategic Framework was adopted by UN-GGIM as the Integrated Geospatial Information Framework (IGIF). The outcome of the Framework’s adoption by UN-GGIM immediately validated its critical need.

9.2.5 Research Objective 5

Demonstrate the utility and implementation of the national strategic geospatial information framework through a case study.

The fifth objective was met through the two-dimensional case study in Chapter 8. This Chapter described how the Strategic Framework, presented as the IGIF, is able to be synthesised, implemented and prototyped – regionally within the continent of Africa, and nationally within the country of Ethiopia. The case study demonstrated the utility and implementation of the IGIF, and how geospatial information can be integrated into national sustainable development policies and strategies. The Chapter further considered the role of the NSDI, as the national geospatial information system of the sustainable development data flow framework, as a means to provide reliable fundamental geospatial data, and to provide both the enabling platform and connection point to other national information systems, and to the SDGs.

9.2.6 Research Objective 6

Evaluate the improvement of the framework and identify areas for future work and directions.

The sixth objective was met through the development of the Strategic Framework and implementation of the IGIF in Chapters 7 and 8, and Section 9.5 below.

The Framework, and now the IGIF, has been iteratively developed and improved over the past three years, firstly as a prototype based on the literature review, then through the case study and multiple consultations and workshops in Africa, and ultimately through the global process of the United Nations, where 133 individual countries formally represented and participated, many several times, in sixteen expert workshops and consultative meetings.

The IGIF has been developed with the knowledge that it will be a living document, to be further refined as technologies, processes, knowledge and experience evolve. Therefore, as a United Nations adopted framework, the IGIF will be maintained and improved in the years ahead.

9.3 Response to the Research Problem and Main Outcomes

The research problem defined in Chapter 1 (Section 1.2.1) recognised that despite the demonstrated demand and urgent global development needs, geospatial information remains unable to adequately contribute its data, systems and integrative capabilities to support the measuring, monitoring and implementation of the SDGs, particularly at a national level.

Through exploratory investigations, this research has confirmed that this problem indeed exists. The literature suggest two key problems. The first is a deficiency in awareness and understanding in connecting two major communities of practice. While sustainable development, and now the SDGs, are well recognised and embedded into national development policy and practice within countries, the understanding and use of geospatial capabilities and enabling technologies are not. The SDGs are highly

visible, and geospatial information is predominantly invisible. The literature suggests that gaps exist, including lack of understanding, leadership, mechanisms to implement, and frustration around what NSDI's are, and are not. It is only in the past few years, through the establishment of UN-GGIM at the global intergovernmental level, that this understanding and leadership, combined with strong communication, is beginning to change. UN-GGIM is beginning to solve the problem.

However, and leading to the second key problem, the literature suggested that the lack of strategic geospatial frameworks are the main institutional issue within national governments and their respective national geospatial agencies. This was confirmed in the case study and consultation workshops. Combined with strong national leadership, broad and inclusive strategic frameworks, that are not too prescriptive, are able to provide the means and guidance to overcoming institutional and professional barriers. While NSDIs have existed and been evolving for some decades, many developing countries have still been trying to catch and implement the NSDI processes as defined twenty years ago, and it is not working. Many NSDIs in countries are no longer functioning as they were originally intended.

The research findings confirmed the need for an overarching national strategic framework that could be general enough to show how many systemic institutional barriers could be addressed through aspirational principles and goals, while also being detailed enough to provide the pragmatic pathways and roadmap to overcome the research problem. The IGIF now provides that framework. While linking to and building upon NSDIs, the strength of the IGIF is that it is not a data infrastructure. It is an integrated framework and a knowledge infrastructure that can be applied to all countries and all situations.

9.4 Contribution to Knowledge

This research provides a considerable body of knowledge into the relationship between sustainable development and geospatial information over the past half century. It also represents the first in-depth investigation into the history of cartography, national mapping and geospatial information within the regional to global United Nations intergovernmental processes, which were initiated in 1948 following World War II. It therefore provides a contribution to an established gap in the current discourse and understanding of the role and relationship of geospatial information in the sustainable development domain. It further provides the foundation for establishing a new research direction for a development agenda that has to date been demanding more timely and reliable data, but has been dominated by political aspirations and decisions that do not yet have this required data and analyses to enable more informed decision and policy-making.

In summary, this research has achieved six key contributions to knowledge:

1. Identification of the evolution and relationship between geospatial information and sustainable development;
2. Revelation of stakeholder needs in applying geospatial information to support national development and sustainable development objectives;
3. Understanding of perceptions, expectations and impediments within the geospatial community to support the measuring and monitoring of the SDGs;
4. Development of the components of the geospatial digital divide and the complex challenges that continue to exacerbate the ability for many developing countries to bridge this divide;
5. Development of a conceptual integrated geospatial information systems framework as an integrative sustainable development data flow which provides the building blocks and processes for countries to measure and monitor the SDGs with relevant and timely data;
6. Development and implementation of a national strategic geospatial information framework that can be immediately implemented and used by all countries to support the strengthening of national geospatial information arrangements and the measuring and monitoring of the SDGs.

9.5 Future Research Directions

Throughout conducting this research, a number of future research opportunities were identified that could not be addressed within the scope of this research. Some of these are associated with the limitations of the research and the research design; others aim to extend the work that has been achieved here.

Further testing and validation of the IGIF and Strategic Pathways

There is opportunity to further analyse and improve the validity and applicability of the different components of the IGIF, how it will be used, and what impacts it may have on policy development in countries. This is particularly relevant to the seven underpinning principles and eight goals. These were developed in this research in a time-bound and limited stakeholder process. This could be expanded further through application in a variety of contexts and through other case studies and geospatial policy settings. This could also lead to refinement and better understanding of the underlying expectations that governments may have on success factors, the measuring of the goals, and perhaps the consequences of making certain strategic choices over others.

Refinement of the Key Elements of the Strategic Pathways

Each of the nine strategic pathways of the IGIF contain four key elements as the enabling components or requirements for the national implementation of the IGIF. Although they have been developed and refined iteratively in consultation with African countries through a series of expert consultations and workshops, consultation with the broader global geospatial community has been limited. More research is required in other regions and sub-regions to test and refine each of the key elements. A further consideration could be that more than four key elements may be required.

Step-by-step guidance on actions for implementation of the IGIF

Step-by-step actions for how each of the strategic pathways and their key elements are operationalised within a country are not described, and are beyond the aims and objectives of this dissertation. While the IGIF Implementation Guide and related Country-level Action Plans are now being developed by UN-GGIM, further research with case studies will assist in continual improvement and validation for countries. This research will assist in testing and confirming a possible current limitation of the IGIF, a more scientific approach and justification for the nine strategic pathways and the four key elements of each pathway.

Linkages of the IGIF with the NSDI

Understanding the linkages of the IGIF with the NSDI formed a key sub-topic of this dissertation. For African countries, understanding the differences between the more traditional (first and second generation) NSDI and IGIF was a vitally important discussion in the consultations and workshops, as many had been attempting to implement and sustain NSDI's within their countries for up to two decades. But the political will, knowledge and understanding to embrace the NSDI concept, and the value of geospatial information has simply not yet been successfully realised. The African countries overwhelmingly welcomed the structure of the IGIF, particularly as there is a complete absence of understanding of key messages and elements that communicate the message and need of NSDIs and geospatial information to decision and policy makers in developing countries. The IGIF, as an integrated framework, allows those countries that have already implemented NSDI capabilities to build upon this existing progress and investment to further develop national geospatial capability. The mere fact that the IGIF has been adopted by the United Nations and embraced so quickly and universally indicates a pent up demand and willingness for countries to embrace new ideas and concepts – as the existing ones (NSDIs) have proven to no longer be relevant or work. This is a critical area in which more detailed research, and potentially a new research agenda, is urgently required. A first step would be to possibly consult with a target group of decision-makers to seek their understanding of a framework such as the IGIF.

Geospatial data to support the global indicator framework

While developing a conceptual integrated geospatial information systems framework as an integrative sustainable development 'data flow' for the SDGs, this research was unable to delve deeper into the data needs of the SDGs more broadly, and did not address how geospatial information could support each of the 232 global indicators as listed in Appendix 1. This is another future research opportunity to be addressed.

Applying the IGIF to sub-national and local situations

The IGIF is presently presented as a ‘national’ strategic framework, and is only applicable and relevant at the national/federal level. There is an opportunity to test its applicability at the sub-national level, and possibly at the local level in the future. As the future of geospatial information develops, there will be a greater emphasis for it to be relevant at the local level and city (community) level.

9.6 Research Outlook

This research documented in this dissertation has drawn on institutional theory, the literatures and a case study to produce new insights into systemic issues that constrain efforts to leverage geospatial information to support the SDGs. While there has been considerable previous research in each of these domains, they have largely been undertaken separately. Previous research connections have largely been dominated by documentation of data gaps and NSDI practices as a data supply process, rather than considering the broader user needs and requirements of sustainable development and the SDGs. The fact that countries are still struggling today to understand and comprehend how to use geospatial information to support the SDGs, five years into the development agenda, attests to this predicament.

This research demonstrated that despite a long history of comparatively mediocre progress, rapid change is possible if sufficient understanding and legitimacy is able to be cultivated around the reasons for change, and that this could be communicated and directed into clear action through incisive leadership and strategic frameworks. The overwhelming support for, and uptake of, the IGIF demonstrates the appetite for change within a greater ‘top down’ and interconnected national structure.

Countries have emphasised the need for coherent and integrated system-wide strategic planning, implementation and reporting. Policy coherence is crucial for achievement of the SDGs, given the interlinked and inseparable nature of the various dimensions and constituent elements involved – social economic and environmental. At the national level, policy coherence ensures consistency across national policy and programme frameworks, and their alignment in support of national sustainable development efforts.

In this regard, the IGIF has been both a catalyst for change and a driver of that change. The IGIF is comprehensive and provides a clear vision and mission on how to develop and facilitate the utilisation and integration of geospatial information at the national level for national needs, including sustainable development. For developing countries, it is proving already to be a valuable tool to be utilised to bridge the geospatial digital divide. Despite its comprehensiveness, the IGIF is clear enough to be used at the highest level. It is considered valuable to identify the seven underpinning principles, eight goals and nine strategic pathways; several countries even expressed interest to expand these further. As a research outlook, this is favourable.

The IGIF will assist in addressing the understanding and knowledge gaps in sustainable development through improving policies, frameworks, systems and data for the collection, analysis and

dissemination of geospatial information to inform decision-makers and evidence-based policy. This Framework proposes an environment where government organisations can cooperate, and thus improve, the management and exchange of geospatial information to support and serve the national interests and enables the value of geospatial information to be realised for sustainable development. In order to be effective and avoid duplication of technology and resources, the Framework needs to be cross-cutting across multiple government agencies, and to leverage existing NSDI capabilities and methodologies; but also, being able to gather and deliver new data not previously considered. The IGIF will also need to be sufficiently agile so that it can be aligned with future societal trends and expectations.

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Appendix 1: Sustainable Development Goals – Targets and Indicators





GOAL 1: END POVERTY IN ALL ITS FORMS EVERYWHERE

TARGETS:

- 1.1 By 2030, eradicate extreme poverty for all people everywhere, currently measured as people living on less than \$1.25 a day.
- 1.2 By 2030, reduce at least by half the proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions.
- 1.3 Implement nationally appropriate social protection systems and measures for all, including floors, and by 2030 achieve substantial coverage of the poor and the vulnerable.
- 1.4 By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property, inheritance, natural resources, appropriate new technology and financial services, including microfinance.
- 1.5 By 2030, build the resilience of the poor and those in vulnerable situations and reduce their exposure and vulnerability to climate-related extreme events and other economic, social and environmental shocks and disasters.
 - 1.a. Ensure significant mobilization of resources from a variety of sources, including through enhanced development cooperation, in order to provide adequate and predictable means for developing countries, in particular least developed countries, to implement programmes and policies to end poverty in all its dimensions.
 - 1.b. Create sound policy frameworks at the national, regional and international levels, based on pro-poor and gender-sensitive development strategies, to support accelerated investment in poverty eradication actions.

INDICATORS:

- 1.1.1 Proportion of the population living below the international poverty line by sex, age, employment status and geographic location (urban/rural).
- 1.2.1 Proportion of population living below the national poverty line, by sex and age.
- 1.2.2 Proportion of men, women and children of all ages living in poverty in all its dimensions according to national definitions.
- 1.3.1 Proportion of population covered by social protection floors/systems, by sex, distinguishing children, unemployed persons, older persons, persons with disabilities, pregnant women, newborns, work-injury victims and the poor and the vulnerable.
- 1.4.1 Proportion of population living in households with access to basic services.
- 1.4.2 Proportion of total adult population with secure tenure rights to land, (a) with legally recognised documentation, and (b) who perceive their rights to land as secure, by sex and type of tenure.
- 1.5.1 Number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 population.
- 1.5.2 Direct economic loss attributed to disasters in relation to global gross domestic product (GDP).
- 1.5.3 Number of countries that adopt and implement national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015–2030.
- 1.5.4 Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies.
- 1.a.1 Total official development assistance grants from all donors that focus on poverty reduction as a share of the recipient country's gross national income.
- 1.a.2 Proportion of total government spending on essential services (education, health and social protection).
- 1.b.1 Pro-poor public social spending.



GOAL 2: END HUNGER, ACHIEVE FOOD SECURITY AND IMPROVED NUTRITION AND PROMOTE SUSTAINABLE AGRICULTURE

TARGETS:

- 2.1 By 2030, end hunger and ensure access by all people, in particular the poor and people in vulnerable situations, including infants, to safe, nutritious and sufficient food all year round.
- 2.2 By 2030, end all forms of malnutrition, including achieving, by 2025, the internationally agreed targets on stunting and wasting in children under 5 years of age, and address the nutritional needs of adolescent girls, pregnant and lactating women and older persons.
- 2.3 By 2030, double the agricultural productivity and incomes of small-scale food producers, in particular women, indigenous peoples, family farmers, pastoralists and fishers, including through secure and equal access to land, other productive resources and inputs, knowledge, financial services, markets and opportunities for value addition and non-farm employment.
- 2.4 By 2030, ensure sustainable food production systems and implement resilient agricultural practices that increase productivity and production, that help maintain ecosystems, that strengthen capacity for adaptation to climate change, extreme weather, drought, flooding and other disasters and that progressively improve land and soil quality.
- 2.5 By 2020, maintain the genetic diversity of seeds, cultivated plants and farmed and domesticated animals and their related wild species, including through soundly managed and diversified seed and plant banks at the national, regional and international levels, and promote access to and fair and equitable sharing of benefits arising from the utilization of genetic resources and associated traditional knowledge, as internationally agreed.

- 2.a. Increase investment, including through enhanced international cooperation, in rural infrastructure, agricultural research and extension services, technology development and plant and livestock gene banks in order to enhance agricultural productive capacity in developing countries, in particular least developed countries.
- 2.b. Correct and prevent trade restrictions and distortions in world agricultural markets, including through the parallel elimination of all forms of agricultural export subsidies and all export measures with equivalent effect, in accordance with the mandate of the Doha Development Round.
- 2.c. Adopt measures to ensure the proper functioning of food commodity markets and their derivatives and facilitate timely access to market information, including on food reserves, in order to help limit extreme food price volatility.

INDICATORS:

- 2.1.1 Prevalence of undernourishment.
- 2.1.2 Prevalence of moderate or severe food insecurity in the population, based on the Food Insecurity Experience Scale (FIES).
- 2.2.1 Prevalence of stunting (height for age <-2 standard deviation from the median of the World Health Organisation (WHO) Child Growth Standards) among children under 5 years of age.
- 2.2.2 Prevalence of malnutrition (weight for height $>+2$ or <-2 standard deviation from the median of the WHO Child Growth Standards) among children under 5 years of age, by type (wasting and overweight).
- 2.2.3 Prevalence of anaemia in women aged 15 to 49 years, by pregnancy status (percentage).
- 2.3.1 Volume of production per labour unit by classes of farming/pastoral/forestry enterprise size.
- 2.3.2 Average income of small-scale food producers, by sex and indigenous status.
- 2.4.1 Proportion of agricultural area under productive and sustainable agriculture.
- 2.5.1 Number of plant and animal genetic resources for food and agriculture secured in either medium - or long - term conservation facilities.
- 2.5.2 Proportion of local breeds classified as being at risk of extinction.
- 2.a.1 The agriculture orientation index for government expenditures.
- 2.a.2 Total official flows (official development assistance plus other official flows) to the agriculture sector.
- 2.b.1 Agricultural export subsidies.

2.c.1 Indicator of food price anomalies.



GOAL 3: ENSURE HEALTHY LIVES AND PROMOTE WELL-BEING FOR ALL AT ALL AGES

TARGETS:

- 3.1 By 2030, reduce the global maternal mortality ratio to less than 70 per 100,000 live births.
- 3.2 By 2030, end preventable deaths of newborns and children under 5 years of age, with all countries aiming to reduce neonatal mortality to at least as low as 12 per 1,000 live births and under-5 mortality to at least as low as 25 per 1,000 live births.
- 3.3 By 2030, end the epidemics of AIDS, tuberculosis, malaria and neglected tropical diseases and combat hepatitis, water-borne diseases and other communicable diseases.
- 3.4 By 2030, reduce by one third premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being.
- 3.5 Strengthen the prevention and treatment of substance abuse, including narcotic drug abuse and harmful use of alcohol.
- 3.6 By 2020, halve the number of global deaths and injuries from road traffic accidents.
- 3.7 By 2030, ensure universal access to sexual and reproductive health-care services, including for family planning, information and education, and the integration of reproductive health into national strategies and programmes.
- 3.8 Achieve universal health coverage, including financial risk protection, access to quality essential health-care services and access to safe, effective, quality and affordable essential medicines and vaccines for all.
- 3.9 By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination.
- 3.a Strengthen the implementation of the World Health Organisation Framework Convention on Tobacco Control in all countries, as appropriate.

- 3.b. Support the research and development of vaccines and medicines for the communicable and non-communicable diseases that primarily affect developing countries, provide access to affordable essential medicines and vaccines, in accordance with the Doha Declaration on the TRIPS Agreement and Public Health, which affirms the right of developing countries to use to the full the provisions in the Agreement on Trade-Related Aspects of Intellectual Property Rights regarding flexibilities to protect public health, and, in particular, provide access to medicines for all.
- 3.c. Substantially increase health financing and the recruitment, development, training and retention of the health workforce in developing countries, especially in least developed countries and small island developing States.
- 3.d. Strengthen the capacity of all countries, in particular developing countries, for early warning, risk reduction and management of national and global health risks.

INDICATORS:

- 3.1.1 Maternal mortality ratio.
- 3.1.2 Proportion of births attended by skilled health personnel.
- 3.2.1 Under-5 mortality rate.
- 3.2.2 Neonatal mortality rate.
- 3.3.1 Number of new HIV infections per 1,000 uninfected population, by sex, age and key populations.
- 3.3.2 Tuberculosis incidence per 100,000 population.
- 3.3.3 Malaria incidence per 1,000 population.
- 3.3.4 Hepatitis B incidence per 100,000 population.
- 3.3.5 Number of people requiring interventions against neglected tropical diseases.
- 3.4.1 Mortality rate attributed to cardiovascular disease, cancer, diabetes or chronic respiratory disease.
- 3.4.2 Suicide mortality rate.
- 3.5.1 Coverage of treatment interventions (pharmacological, psychosocial and rehabilitation and aftercare services) for substance use disorders.
- 3.5.2 Alcohol per capita consumption (aged 15 years and older) within a calendar year in litres of pure alcohol.
- 3.6.1 Death rate due to road traffic injuries.
- 3.7.1 Proportion of women of reproductive age (aged 15–49 years) who have their need for family planning satisfied with modern methods.

- 3.7.2 Adolescent birth rate (aged 10–14 years; aged 15–19 years) per 1,000 women in that age group.
- 3.8.1 Coverage of essential health services.
- 3.8.2 Proportion of population with large household expenditures on health as a share of total household expenditure or income.
- 3.9.1 Mortality rate attributed to household and ambient air pollution.
- 3.9.2 Mortality rate attributed to unsafe water, unsafe sanitation and lack of hygiene (exposure to unsafe Water, Sanitation and Hygiene for All (WASH) services).
- 3.9.3 Mortality rate attributed to unintentional poisoning.
- 3.a.1 Age-standardized prevalence of current tobacco use among persons aged 15 years and older.
- 3.b.1 Proportion of the target population covered by all vaccines included in their national programme.
- 3.b.2 Total net official development assistance to medical research and basic health sectors.
- 3.b.3 Proportion of health facilities that have a core set of relevant essential medicines available and affordable on a sustainable basis.
- 3.c.1 Health worker density and distribution.
- 3.d.1 International Health Regulations (IHR) capacity and health emergency preparedness.
- 3.d.2 Percentage of bloodstream infections due to selected antimicrobial-resistant organisms.



GOAL 4: ENSURE INCLUSIVE AND EQUITABLE QUALITY EDUCATION AND PROMOTE LIFELONG LEARNING OPPORTUNITIES FOR ALL

TARGETS:

- 4.1 By 2030, ensure that all girls and boys complete free, equitable and quality primary and secondary education leading to relevant and effective learning outcomes.
- 4.2 By 2030, ensure that all girls and boys have access to quality early childhood development, care and pre-primary education so that they are ready for primary education.
- 4.3 By 2030, ensure equal access for all women and men to affordable and quality technical, vocational and tertiary education, including university.
- 4.4 By 2030, substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship.
- 4.5 By 2030, eliminate gender disparities in education and ensure equal access to all levels of education and vocational training for the vulnerable, including persons with disabilities, indigenous peoples and children in vulnerable situations.
- 4.6 By 2030, ensure that all youth and a substantial proportion of adults, both men and women, achieve literacy and numeracy.
- 4.7 By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and non-violence, global citizenship and appreciation of cultural diversity and of culture's contribution to sustainable development.
- 4.a Build and upgrade education facilities that are child, disability and gender sensitive and provide safe, non-violent, inclusive and effective learning environments for all.

- 4.b By 2020, substantially expand globally the number of scholarships available to developing countries, in particular least developed countries, small island developing States and African countries, for enrolment in higher education, including vocational training and information and communications technology, technical, engineering and scientific programmes, in developed countries and other developing countries.
- 4.c By 2030, substantially increase the supply of qualified teachers, including through international cooperation for teacher training in developing countries, especially least developed countries and small island developing States.

INDICATORS:

- 4.1.1 Proportion of children and young people (a) in grades 2/3; (b) at the end of primary; and (c) at the end of lower secondary achieving at least a minimum proficiency level in (i) reading and (ii) mathematics, by sex.
- 4.1.2 Completion rate (primary education, lower secondary education, upper secondary education).
- 4.2.1 Proportion of children aged 24-59 months who are developmentally on track in health, learning and psychosocial well-being, by sex.
- 4.2.2 Participation rate in organised learning (one year before the official primary entry age), by sex.
- 4.3.1 Participation rate of youth and adults in formal and non-formal education and training in the previous 12 months, by sex.
- 4.4.1 Proportion of youth and adults with information and communications technology (ICT) skills, by type of skill.
- 4.5.1 Parity indices (female/male, rural/urban, bottom/top wealth quintile and others such as disability status, indigenous peoples and conflict-affected, as data become available) for all education indicators on this list that can be disaggregated.
- 4.6.1 Proportion of population in a given age group achieving at least a fixed level of proficiency in functional (a) literacy and (b) numeracy skills, by sex.
- 4.7.1 Extent to which (i) global citizenship education and (ii) education for sustainable development are mainstreamed in (a) national education policies; (b) curricula; (c) teacher education; and (d) student assessment.
- 4.a.1 Proportion of school offering basic services, by types of service.
- 4.b.1 Volume of official development assistance flows for scholarships by sector and type of study.

4.c.1 Proportion of teachers with the minimum required qualification, by education level.



GOAL 5: ACHIEVE GENDER EQUALITY AND EMPOWER ALL WOMEN AND GIRLS

TARGETS:

- 5.1 End all forms of discrimination against all women and girls everywhere.
- 5.2 Eliminate all forms of violence against all women and girls in the public and private spheres, including trafficking and sexual and other types of exploitation.
- 5.3 Eliminate all harmful practices, such as child, early and forced marriage and female genital mutilation.
- 5.4 Recognise and value unpaid care and domestic work through the provision of public services, infrastructure and social protection policies and the promotion of shared responsibility within the household and the family as nationally appropriate.
- 5.5 Ensure women's full and effective participation and equal opportunities for leadership at all levels of decision-making in political, economic and public life.
- 5.6 Ensure universal access to sexual and reproductive health and reproductive rights as agreed in accordance with the Programme of Action of the International Conference on Population and Development and the Beijing Platform for Action and the outcome documents of their review conferences.
- 5.a Undertake reforms to give women equal rights to economic resources, as well as access to ownership and control over land and other forms of property, financial services, inheritance and natural resources, in accordance with national laws.
- 5.b Enhance the use of enabling technology, in particular information and communications technology, to promote the empowerment of women.
- 5.c Adopt and strengthen sound policies and enforceable legislation for the promotion of gender equality and the empowerment of all women and girls at all levels.

INDICATORS:

- 5.1.1 Whether or not legal frameworks are in place to promote, enforce and monitor equality and non-discrimination on the basis of sex.
- 5.2.1 Proportion of ever-partnered women and girls aged 15 years and older subjected to physical, sexual or psychological violence by a current or former intimate partner in the previous 12 months, by form of violence and by age.
- 5.2.2 Proportion of women and girls aged 15 years and older subjected to sexual violence by persons other than an intimate partner in the previous 12 months, by age and place of occurrence.
- 5.3.1 Proportion of women aged 20–24 years who were married or in a union before age 15 and before age 18.
- 5.3.2 Proportion of girls and women aged 15–49 years who have undergone female genital mutilation/cutting, by age.
- 5.4.1 Proportion of time spent on unpaid domestic care work, by sex, age and location.
- 5.5.1 Proportion of the seats held by women in (a) national parliaments and (b) local governments.
- 5.5.2 Proportion of women in managerial positions.
- 5.6.1 Proportion of women aged 15–49 years who make their own informed decisions regarding sexual relations, contraceptive use and reproductive health care.
- 5.6.2 Number of countries with laws and regulations that guarantee full and equal access to women and men aged 15 years and older to sexual and reproductive health care, information and education.
- 5.a.1 (a) Proportion of total agricultural population with ownership or secure rights over agricultural land, by sex; and (b) share of women among owners or rights-bearers of agricultural land, by type of tenure.
- 5.a.2 Proportion of countries where the legal framework (including customary law) guarantees women's equal rights to land ownership and/or control.
- 5.b.1 Proportion of individuals who own a mobile telephone, by sex.
- 5.c.1 Proportion of countries with systems to track and make public allocations for gender equality and women's empowerment.



GOAL 6: ENSURE AVAILABILITY AND SUSTAINABLE MANAGEMENT OF WATER AND SANITATION FOR ALL

TARGETS:

- 6.1 By 2030, achieve universal and equitable access to safe and affordable drinking water for all.
- 6.2 By 2030, achieve access to adequate and equitable sanitation and hygiene for all and end open defecation, paying special attention to the needs of women and girls and those in vulnerable situations.
- 6.3 By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally.
- 6.4 By 2030, substantially increase water-use efficiency across all sectors and ensure sustainable withdrawals and supply of freshwater to address water scarcity and substantially reduce the number of people suffering from water scarcity.
- 6.5 By 2030, implement integrated water resources management at all levels, including through transboundary cooperation as appropriate.
- 6.6 By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes.
- 6.a By 2030, expand international cooperation and capacity-building support to developing countries in water-and sanitation-related activities and programmes, including water harvesting, desalination, water efficiency, wastewater treatment, recycling and reuse technologies.
- 6.b Support and strengthen the participation of local communities in improving water and sanitation management.

INDICATORS:

- 6.1.1 Proportion of population using safely managed drinking water services.
- 6.2.1 Proportion of population using (a) safely managed sanitation services and (b) a hand-washing facility with soap and water.
- 6.3.1 Proportion of domestic and industrial wastewater flows safely treated.
- 6.3.2 Proportion of bodies of water with good ambient water quality.
- 6.4.1 Change in water-use efficiency over time.
- 6.4.2 Level of water stress: freshwater withdrawal as a proportion of available freshwater resources.
- 6.5.1 Degree of integrated water resources management.
- 6.5.1 Proportion of transboundary basin area with an operational arrangement for water cooperation.
- 6.6.1 Change in the extent of water-related ecosystems over time.
- 6.a.1 Amount of water-and sanitation-related official development assistance that is part of a government-coordinated spending plan.
- 6.b.1 Proportion of local administrative units with established and operational policies and procedures for participation of local communities in water and sanitation management.



GOAL 7: ENSURE ACCESS TO AFFORDABLE, RELIABLE AND MODERN ENERGY FOR ALL

TARGETS:

- 7.1 By 2030, ensure universal access to affordable, reliable and modern energy services.
- 7.2 By 2030, increase substantially the share of renewable energy in the global energy mix.
- 7.3 By 2030, double the global rate of improvement in energy efficiency.
- 7.a By 2030, enhance international cooperation to facilitate access to clean energy research and technology, including renewable energy, energy efficiency and advanced and cleaner fossil-fuel technology, and promote investment in energy infrastructure and clean energy technology.
- 7.b By 2030, expand infrastructure and upgrade technology for supplying modern and sustainable energy services for all in developing countries, in particular least developed countries, small island developing States and landlocked developing countries, in accordance with their respective programmes of support.

INDICATORS:

- 7.1.1 Proportion of population with access to electricity.
- 7.1.2 Proportion of population with primary reliance on clean fuels and technology.
- 7.2.1 Renewable energy share in the total final energy consumption.
- 7.3.1 Energy intensity measured in terms of primary energy and GDP.
- 7.a.1 International financial flows to developing countries in support of clean energy research and development and renewable energy production, including in hybrid systems.
- 7.b.1 Installed renewable energy-generating capacity in developing countries (in watts per capita).

8 DECENT WORK AND ECONOMIC GROWTH



GOAL 8: PROMOTE SUSTAINED, INCLUSIVE AND SUSTAINABLE ECONOMIC GROWTH, FULL AND PRODUCTIVE EMPLOYMENT AND DECENT WORK FOR ALL

TARGETS:

- 8.1 Sustain per capita economic growth in accordance with national circumstances and, in particular, at least 7 per cent gross domestic product growth per annum in the least developed countries.
- 8.2 Achieve higher levels of economic productivity through diversification, technological upgrading and innovation, including through a focus on high-value added and labour-intensive sectors.
- 8.3 Promote development-oriented policies that support productive activities, decent job creation, entrepreneurship, creativity and innovation, and encourage the formalization and growth of micro-, small- and medium-sized enterprises, including through access to financial services.
- 8.4 Improve progressively, through 2030, global resource efficiency in consumption and production and endeavour to decouple economic growth from environmental degradation, in accordance with the 10-Year Framework of Programmes on Sustainable Consumption and Production, with developed countries taking the lead.
- 8.5 By 2030, achieve full and productive employment and decent work for all women and men, including for young people and persons with disabilities, and equal pay for work of equal value.
- 8.6 By 2020, substantially reduce the proportion of youth not in employment, education or training.
- 8.7 Take immediate and effective measures to eradicate forced labour, end modern slavery and human trafficking and secure the prohibition and elimination of the worst forms of

child labour, including recruitment and use of child soldiers, and by 2025 end child labour in all its forms.

- 8.8 Protect labour rights and promote safe and secure working environments for all workers, including migrant workers, in particular women migrants, and those in precarious employment.
- 8.9 By 2030, devise and implement policies to promote sustainable tourism that creates jobs and promotes local culture and products.
- 8.10 Strengthen the capacity of domestic financial institutions to encourage and expand access to banking, insurance and financial services for all.
- 8.a Increase Aid for Trade support for developing countries, in particular least developed countries, including through the Enhanced Integrated Framework for Trade-related Technical Assistance to Least Developed Countries.
- 8.b By 2020, develop and operationalise a global strategy for youth employment and implement the Global Jobs Pact of the International Labour Organisation.

INDICATORS:

- 8.1.1 Annual growth rate of real GDP per capita.
- 8.2.1 Annual growth rate of real GDP per employed person.
- 8.3.1 Proportion of informal employment in total employment, by sector and sex.
- 8.4.1 Material footprint, material footprint per capita, and material footprint per GDP.
- 8.4.2 Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP.
- 8.5.1 Average hourly earnings of employees, by sex, age, occupation and persons with disabilities.
- 8.5.2 Unemployment rate, by sex, age and persons with disabilities.
- 8.6.1 Proportion of youth (aged 15–24 years) not in education, employment or training.
- 8.7.1 Proportion and number of children aged 5–17 years engaged in child labour, by sex and age.
- 8.8.1 Fatal and non-fatal occupational injuries per 100,000 workers, by sex and migrant status.
- 8.8.2 Level of national compliance with labour rights (freedom of association and collective bargaining) based on International Labour Organisation (ILO) textual sources and national legislation, by sex and migrant status.
- 8.9.1 Tourism direct GDP as a proportion of total GDP and in growth rate.

- 8.10.1 (a) Number of commercial bank branches per 100,000 adults and (b) number of automated teller machines (ATMs) per 100,000 adults.
- 8.10.2 Proportion of adults (15 years and older) with an account at a bank or other financial institution or with a mobile-money-service provider.
- 8.a.1 Aid for Trade commitments and disbursements.
- 8.b.1 Existence of a developed and operationalised national strategy for youth employment, as a distinct strategy or as part of a national employment strategy.

9 INDUSTRY, INNOVATION AND INFRASTRUCTURE



GOAL 9: BUILD RESILIENT INFRASTRUCTURE, PROMOTE INCLUSIVE AND SUSTAINABLE INDUSTRIALIZATION AND FOSTER INNOVATION

TARGETS:

- 9.1 Develop quality, reliable, sustainable and resilient infrastructure, including regional and transborder infrastructure, to support economic development and human well-being, with a focus on affordable and equitable access for all.
- 9.2 Promote inclusive and sustainable industrialization and, by 2030, significantly raise industry's share of employment and gross domestic product, in line with national circumstances, and double its share in least developed countries.
- 9.3 Increase the access of small-scale industrial and other enterprises, in particular in developing countries, to financial services, including affordable credit, and their integration into value chains and markets.
- 9.4 By 2030, upgrade infrastructure and retrofit industries to make them sustainable, with increased resource-use efficiency and greater adoption of clean and environmentally sound technologies and industrial processes, with all countries taking action in accordance with their respective capabilities.
- 9.5 Enhance scientific research, upgrade the technological capabilities of industrial sectors in all countries, in particular developing countries, including, by 2030, encouraging innovation and substantially increasing the number of research and development workers per 1 million people and public and private research and development spending.
- 9.a Facilitate sustainable and resilient infrastructure development in developing countries through enhanced financial, technological and technical support to African countries, least developed countries, landlocked developing countries and small island developing States.

- 9.b Support domestic technology development, research and innovation in developing countries, including by ensuring a conducive policy environment for, inter alia, industrial diversification and value addition to commodities.
- 9.c Significantly increase access to information and communications technology and strive to provide universal and affordable access to the Internet in least developed countries by 2020.

INDICATORS:

- 9.1.1 Proportion of the rural population who live within 2km of an all-season road.
- 9.1.2 Passenger and freight volumes, by mode of transport.
- 9.2.1 Manufacturing value added as a proportion of GDP and per capita.
- 9.2.2 Manufacturing employment as a proportion of total employment.
- 9.3.1 Proportion of small-scale industries in total industry value added.
- 9.3.2 Proportion of small-scale industries with a loan or line of credit.
- 9.4.1 CO2 emission per unit of value added.
- 9.5.1 Research and development expenditure as a proportion of GDP.
- 9.5.2 Researchers (in full-time equivalent) per million inhabitants
- 9.a.1 Total official international support (official development assistance plus other official flows) to infrastructure.
- 9.b.1 Proportion of medium and high-tech industry value added in total value added.
- 9.c.1 Proportion of population covered by a mobile network, by technology.



GOAL 10: REDUCE INEQUALITY WITHIN AND AMONG COUNTRIES

TARGETS:

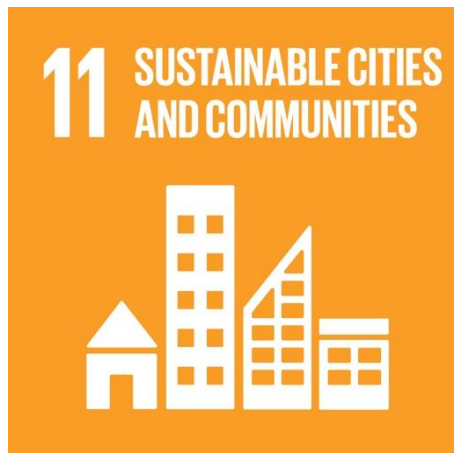
- 10.1 By 2030, progressively achieve and sustain income growth of the bottom 40 per cent of the population at a rate higher than the national average.
- 10.2 By 2030, empower and promote the social, economic and political inclusion of all, irrespective of age, sex, disability, race, ethnicity, origin, religion or economic or other status.
- 10.3 Ensure equal opportunity and reduce inequalities of outcome, including by eliminating discriminatory laws, policies and practices and promoting appropriate legislation, policies and action in this regard.
- 10.4 Adopt policies, especially fiscal, wage and social protection policies, and progressively achieve greater equality.
- 10.5 Improve the regulation and monitoring of global financial markets and institutions and strengthen the implementation of such regulations.
- 10.6 Ensure enhanced representation and voice for developing countries in decision-making in global international economic and financial institutions in order to deliver more effective, credible, accountable and legitimate institutions.
- 10.7 Facilitate orderly, safe, regular and responsible migration and mobility of people, including through the implementation of planned and well-managed migration policies.
- 10.a Implement the principle of special and differential treatment for developing countries, in particular least developed countries, in accordance with World Trade Organisation agreements.
- 10.b Encourage official development assistance and financial flows, including foreign direct investment, to States where the need is greatest, in particular least developed countries,

African countries, small island developing States and landlocked developing countries, in accordance with their national plans and programmes

- 10.c By 2030, reduce to less than 3 per cent the transaction costs of migrant remittances and eliminate remittance corridors with costs higher than 5 per cent.

INDICATORS:

- 10.1.1 Growth rates of household expenditure or income per capita among the bottom 40 per cent of the population and the total population.
- 10.2.1 Proportion of people living below 50 per cent of median income, by sex, age and persons with disabilities.
- 10.3.1 Proportion of population reporting having personally felt discriminated against or harassed in the previous 12 months on the basis of a ground of discrimination prohibited under international human rights law.
- 10.4.1 Labour share of GDP.
- 10.4.2 Redistributive impact of fiscal policy.
- 10.5.1 Financial Soundness Indicators.
- 10.6.1 Proportion of members and voting rights of developing countries in international organisations.
- 10.7.1 Recruitment cost borne by employee as a proportion of monthly income earned in country of destination.
- 10.7.2 Number of countries with migration policies that facilitate orderly, safe, regular and responsible migration and mobility of people.
- 10.7.3 Number of people who died or disappeared in the process of migration towards an international destination.
- 10.7.4 Proportion of the population who are refugees, by country of origin.
- 10.a.1 Proportion of tariff lines applied to imports from least developed countries and developing countries with zero-tariff.
- 10.b.1 Total resource flows for development, by recipient and donor countries and type of flow (e.g. official development assistance, foreign direct investment and other flows).
- 10.c.1 Remittance costs as a proportion of the amount remitted.



GOAL 11: MAKE CITIES AND HUMAN SETTLEMENTS INCLUSIVE, SAFE, RESILIENT AND SUSTAINABLE

TARGETS:

- 11.1 By 2030, ensure access for all to adequate, safe and affordable housing and basic services and upgrade slums.
- 11.2 By 2030, provide access to safe, affordable, accessible and sustainable transport systems for all, improving road safety, notably by expanding public transport, with special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons.
- 11.3 By 2030, enhance inclusive and sustainable urbanization and capacity for participatory, integrated and sustainable human settlement planning and management in all countries.
- 11.4 Strengthen efforts to protect and safeguard the world's cultural and natural heritage.
- 11.5 By 2030, significantly reduce the number of deaths and the number of people affected and substantially decrease the direct economic losses relative to global gross domestic product caused by disasters, including water-related disasters, with a focus on protecting the poor and people in vulnerable situations.
- 11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management.
- 11.7 By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities.
- 11.a Support positive economic, social and environmental links between urban, peri-urban and rural areas by strengthening national and regional development planning.
- 11.b By 2020, substantially increase the number of cities and human settlements adopting and implementing integrated policies and plans towards inclusion, resource efficiency, mitigation and adaptation to climate change, resilience to disasters, and develop and

implement, in line with the Sendai Framework for Disaster Risk Reduction 2015–2030, holistic disaster risk management at all levels.

- 11.c Support least developed countries, including through financial and technical assistance, in building sustainable and resilient buildings utilizing local materials.

INDICATORS:

- 11.1.1 Proportion of urban population living in slums, informal settlements or inadequate housing.
- 11.2.1 Proportion of population that has convenient access to public transport, by sex, age and persons with disabilities.
- 11.3.1 Ratio of land consumption rate to population growth rate.
- 11.3.2 Proportion of cities with a direct participation structure of civil society in urban planning and management that operate regularly and democratically.
- 11.4.1 Total per capita expenditure on the preservation, protection and conservation of all cultural and natural heritage, by source of funding (public, private), type of heritage (cultural, natural) and level of government (national, regional, and local/municipal).
- 11.5.1 Number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 population.
- 11.5.2 Direct economic loss in relation to global GDP, damage to critical infrastructure and number of disruptions to basic services, attributed to disasters.
- 11.6.1 Proportion of municipal solid waste collected and managed in controlled facilities out of total municipal waste generated, by cities.
- 11.6.2 Annual mean levels of fine particulate matter (e.g. PM2.5 and PM10) in cities (population weighted).
- 11.7.1 Average share of the built-up area of cities that is open space for public use for all, by sex, age and persons with disabilities.
- 11.7.2 Proportion of persons victim of physical or sexual harassment, by sex, age, disability status and place of occurrence, in the previous 12 months.
- 11.a.1 Number of countries that have national urban policies or regional development plans that (a) respond to population dynamics; (b) ensure balanced territorial development; and (c) increase local fiscal space.
- 11.b.1 Number of countries that adopt and implement national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015–2030.

11.b.2 Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies.



GOAL 12: ENSURE SUSTAINABLE CONSUMPTION AND PRODUCTION PATTERNS

TARGETS:

- 12.1 Implement the 10-Year Framework of Programmes on Sustainable Consumption and Production Patterns, all countries taking action, with developed countries taking the lead, taking into account the development and capabilities of developing countries.
- 12.2 By 2030, achieve the sustainable management and efficient use of natural resources.
- 12.3 By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses.
- 12.4 By 2020, achieve the environmentally sound management of chemicals and all wastes throughout their life cycle, in accordance with agreed international frameworks, and significantly reduce their release to air, water and soil in order to minimize their adverse impacts on human health and the environment.
- 12.5 By 2030, substantially reduce waste generation through prevention, reduction, recycling and reuse.
- 12.6 Encourage companies, especially large and transnational companies, to adopt sustainable practices and to integrate sustainability information into their reporting cycle.
- 12.7 Promote public procurement practices that are sustainable, in accordance with national policies and priorities.
- 12.8 By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature.
- 12.a Support developing countries to strengthen their scientific and technological capacity to move towards more sustainable patterns of consumption and production.
- 12.b Develop and implement tools to monitor sustainable development impacts for sustainable tourism that creates jobs and promotes local culture and products.

- 12.c Rationalize inefficient fossil-fuel subsidies that encourage wasteful consumption by removing market distortions, in accordance with national circumstances, including by restructuring taxation and phasing out those harmful subsidies, where they exist, to reflect their environmental impacts, taking fully into account the specific needs and conditions of developing countries and minimizing the possible adverse impacts on their development in a manner that protects the poor and the affected communities.

INDICATORS:

- 12.1.1 Number of countries developing, adopting or implementing policy instruments aimed at supporting the shift to sustainable consumption and production.
- 12.2.1 Material footprint, material footprint per capita, and material footprint per GDP.
- 12.2.2 Domestic material consumption, domestic material consumption per capita, and domestic material consumption per GDP.
- 12.3.1 (a) Food loss index and (b) food waste index.
- 12.4.1 Number of parties to international multilateral environmental agreements on hazardous waste, and other chemicals that meet their commitments and obligations in transmitting information as required by each relevant agreement.
- 12.4.2 (a) Hazardous waste generated per capita; and (b) proportion of hazardous waste treated, by type of treatment.
- 12.5.1 National recycling rate, tons of material recycled.
- 12.6.1 Number of companies publishing sustainability reports.
- 12.7.1 Degree of sustainable public procurement policies and action plan implementation.
- 12.8.1 Extent to which (i) global citizenship education and (ii) education for sustainable development are mainstreamed in (a) national education policies; (b) curricula; (c) teacher education; and (d) student assessment.
- 12.a.1 Installed renewable energy-generating capacity in developing countries (in watts per capita).
- 12.b.1 Implementation of standard accounting tools to monitor the economic and environmental aspects of tourism sustainability.
- 12.c.1 Amount of fossil-fuel subsidies per unit of GDP (production and consumption).



GOAL 13: TAKE URGENT ACTION TO COMBAT CLIMATE CHANGE AND ITS IMPACTS

TARGETS:

- 13.1 Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries.
- 13.2 Integrate climate change measures into national policies, strategies and planning.
- 13.3 Improve education, awareness-raising and human and institutional capacity on climate change mitigation, adaptation, impact reduction and early warning.
- 13.a Implement the commitment undertaken by developed-country parties to the United Nations Framework Convention on Climate Change to a goal of mobilizing jointly \$100 billion annually by 2020 from all sources to address the needs of developing countries in the context of meaningful mitigation actions and transparency on implementation and fully operationalise the Green Climate Fund through its capitalization as soon as possible.
- 13.b Promote mechanisms for raising capacity for effective climate change-related planning and management in least developed countries and small island developing States, including focusing on women, youth and local and marginalized communities.

INDICATORS:

- 13.1.1 Number of deaths, missing persons and directly affected persons attributed to disasters per 100,000 population.
- 13.1.2 Number of countries that adopt and implement national disaster risk reduction strategies in line with the Sendai Framework for Disaster Risk Reduction 2015–2030.
- 13.1.3 Proportion of local governments that adopt and implement local disaster risk reduction strategies in line with national disaster risk reduction strategies.

- 13.2.1 Number of countries with nationally determined contributions, long-term strategies, national adaptation plans, strategies as reported in adaptation communications and national communications.
- 13.2.2 Total greenhouse gas emissions per year.
- 13.3.1 Extent to which (i) global citizenship education and (ii) education for sustainable development are mainstreamed in (a) national education policies; (b) curricula; (c) teacher education; and (d) student assessment.
- 13.a.1 Amounts provided and mobilized in United States dollars per year in relation to the continued existing collective mobilization goal of the \$100 billion commitment through to 2025.
- 13.b.1 Number of least developed countries and small island developing States with nationally determined contributions, long-term strategies, national adaptation plans, strategies as reported in adaptation communications and national communications.



GOAL 14: CONSERVE AND SUSTAINABLY USE THE OCEANS, SEAS AND MARINE RESOURCES FOR SUSTAINABLE DEVELOPMENT

TARGETS:

- 14.1 By 2025, prevent and significantly reduce marine pollution of all kinds, in particular from land-based activities, including marine debris and nutrient pollution.
- 14.2 By 2020, sustainably manage and protect marine and coastal ecosystems to avoid significant adverse impacts, including by strengthening their resilience, and take action for their restoration in order to achieve healthy and productive oceans.
- 14.3 Minimize and address the impacts of ocean acidification, including through enhanced scientific cooperation at all levels.
- 14.4 By 2020, effectively regulate harvesting and end overfishing, illegal, unreported and unregulated fishing and destructive fishing practices and implement science-based management plans, in order to restore fish stocks in the shortest time feasible, at least to levels that can produce maximum sustainable yield as determined by their biological characteristics.
- 14.5 By 2020, conserve at least 10 per cent of coastal and marine areas, consistent with national and international law and based on the best available scientific information.
- 14.6 By 2020, prohibit certain forms of fisheries subsidies which contribute to overcapacity and overfishing, eliminate subsidies that contribute to illegal, unreported and unregulated fishing and refrain from introducing new such subsidies, recognising that appropriate and effective special and differential treatment for developing and least developed countries should be an integral part of the World Trade Organisation fisheries subsidies negotiation.
- 14.7 By 2030, increase the economic benefits to small island developing States and least developed countries from the sustainable use of marine resources, including through sustainable management of fisheries, aquaculture and tourism.

- 14.a Increase scientific knowledge, develop research capacity and transfer marine technology, taking into account the Intergovernmental Oceanographic Commission Criteria and Guidelines on the Transfer of Marine Technology, in order to improve ocean health and to enhance the contribution of marine biodiversity to the development of developing countries, in particular small island developing States and least developed countries.
- 14.b Provide access for small-scale artisanal fishers to marine resources and markets.
- 14.c Enhance the conservation and sustainable use of oceans and their resources by implementing international law as reflected in the United Nations Convention on the Law of the Sea, which provides the legal framework for the conservation and sustainable use of oceans and their resources, as recalled in paragraph 158 of “The future we want”.

INDICATORS:

- 14.1.1 (a) Index of coastal eutrophication; and (b) plastic debris density.
- 14.2.1 Number of countries using ecosystem-based approaches to managing marine areas.
- 14.3.1 Average marine acidity (pH) measured at agreed suite of representative sampling stations.
- 14.4.1 Proportion of fish stocks within biologically sustainable levels.
- 14.5.1 Coverage of protected areas in relation to marine areas.
- 14.6.1 Degree of implementation of international instruments aiming to combat illegal, unreported and unregulated fishing.
- 14.7.1 Sustainable fisheries as a proportion of GDP in small island developing States, least developed countries and all countries.
- 14.a.1 Proportion of total research budget allocated to research in the field of marine technology.
- 14.b.1 Degree of application of a legal/regulatory/policy/institutional framework which recognises and protects access rights for small-scale fisheries.
- 14.c.1 Number of countries making progress in ratifying, accepting and implementing through legal, policy and institutional frameworks, ocean-related instruments that implement international law, as reflected in the United Nations Convention on the Law of the Sea, for the conservation and sustainable use of the oceans and their resources.



GOAL 15: PROTECT, RESTORE AND PROMOTE SUSTAINABLE USE OF TERRESTRIAL ECOSYSTEMS, SUSTAINABLY MANAGE FORESTS, COMBAT DESERTIFICATION, AND HALT AND REVERSE LAND DEGRADATION AND HALT BIODIVERSITY LOSS

TARGETS:

- 15.1 By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements.
- 15.2 By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally.
- 15.3 By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world.
- 15.4 By 2030, ensure the conservation of mountain ecosystems, including their biodiversity, in order to enhance their capacity to provide benefits that are essential for sustainable development.
- 15.5 Take urgent and significant action to reduce the degradation of natural habitats, halt the loss of biodiversity and, by 2020, protect and prevent the extinction of threatened species.
- 15.6 Promote fair and equitable sharing of the benefits arising from the utilization of genetic resources and promote appropriate access to such resources, as internationally agreed.
- 15.7 Take urgent action to end poaching and trafficking of protected species of flora and fauna and address both demand and supply of illegal wildlife products.
- 15.8 By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species.

- 15.9 By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts.
- 15.a Mobilize and significantly increase financial resources from all sources to conserve and sustainably use biodiversity and ecosystems.
- 15.b Mobilize significant resources from all sources and at all levels to finance sustainable forest management and provide adequate incentives to developing countries to advance such management, including for conservation and reforestation.
- 15.c Enhance global support for efforts to combat poaching and trafficking of protected species, including by increasing the capacity of local communities to pursue sustainable livelihood opportunities.

INDICATORS:

- 15.1.1 Forest area as a proportion of total land area
- 15.1.2 Proportion of important sites for terrestrial and freshwater biodiversity that are covered by protected areas, by ecosystem type.
- 15.2.1 Progress towards sustainable forest management.
- 15.3.1 Proportion of land that is degraded over total land area.
- 15.4.1 Coverage by protected areas of important sites for mountain biodiversity.
- 15.4.2 Mountain Green Cover Index.
- 15.5.1 Red List Index.
- 15.6.1 Number of countries that have adopted legislative, administrative and policy frameworks to ensure fair and equitable sharing of benefits.
- 15.7.1 Proportion of traded wildlife that was poached or illicitly trafficked.
- 15.8.1 Proportion of countries adopting relevant national legislation and adequately resourcing the prevention or control of invasive alien species.
- 15.9.1 (a) Number of countries that have established national targets in accordance with or similar to Aichi Biodiversity Target 2 of the Strategic Plan for Biodiversity 2011–2020 in their national biodiversity strategy and action plans and the progress reported towards these targets; and (b) integration of biodiversity into national accounting and reporting systems, defined as implementation of the System of Environmental-Economic Accounting.
- 15.a.1 (a) Official development assistance on conservation and sustainable use of biodiversity; and (b) revenue generated and finance mobilized from biodiversity-relevant economic instruments.

- 15.b.1 (a) Official development assistance on conservation and sustainable use of biodiversity;
and (b) revenue generated and finance mobilized from biodiversity-relevant economic
instruments.
- 15.c.1 Proportion of traded wildlife that was poached or illicitly trafficked.



GOAL 16: PROMOTE PEACEFUL AND INCLUSIVE SOCIETIES FOR SUSTAINABLE DEVELOPMENT, PROVIDE ACCESS TO JUSTICE FOR ALL AND BUILD EFFECTIVE, ACCOUNTABLE AND INCLUSIVE INSTITUTIONS AT ALL LEVELS

TARGETS:

- 16.1 Significantly reduce all forms of violence and related death rates everywhere.
- 16.2 End abuse, exploitation, trafficking and all forms of violence against and torture of children.
- 16.3 Promote the rule of law at the national and international levels and ensure equal access to justice for all.
- 16.4 By 2030, significantly reduce illicit financial and arms flows, strengthen the recovery and return of stolen assets and combat all forms of organised crime.
- 16.5 Substantially reduce corruption and bribery in all their forms.
- 16.6 Develop effective, accountable and transparent institutions at all levels.
- 16.7 Ensure responsive, inclusive, participatory and representative decision-making at all levels.
- 16.8 Broaden and strengthen the participation of developing countries in the institutions of global governance.
- 16.9 By 2030, provide legal identity for all, including birth registration.
- 16.10 Ensure public access to information and protect fundamental freedoms, in accordance with national legislation and international agreements.
- 16.a Strengthen relevant national institutions, including through international cooperation, for building capacity at all levels, in particular in developing countries, to prevent violence and combat terrorism and crime.
- 16.b Promote and enforce non-discriminatory laws and policies for sustainable development.

INDICATORS:

- 16.1.1 Number of victims of intentional homicide per 100,000 population, by sex and age.
- 16.1.2 Conflict-related deaths per 100,000 population, by sex, age and cause.
- 16.1.3 Proportion of population subjected to (a) physical violence, (b) psychological violence and (c) sexual violence in the previous 12 months.
- 16.1.4 Proportion of population that feel safe walking alone around the area they live.
- 16.2.1 Proportion of children aged 1–17 years who experienced any physical punishment and/or psychological aggression by caregivers in the past month.
- 16.2.2 Number of victims of human trafficking per 100,000 population, by sex, age and form of exploitation.
- 16.2.3 Proportion of young women and men aged 18–29 years who experienced sexual violence by age 18.
- 16.3.1 Proportion of victims of violence in the previous 12 months who reported their victimization to competent authorities or other officially recognised conflict resolution mechanisms.
- 16.3.2 Unsentenced detainees as a proportion of overall prison population.
- 16.3.3 Proportion of the population who have experienced a dispute in the past two years and who accessed a formal or informal dispute resolution mechanism, by type of mechanism.
- 16.4.1 Total value of inward and outward illicit financial flows (in current United States dollars).
- 16.4.2 Proportion of seized, found or surrendered arms whose illicit origin or context has been traced or established by a competent authority in line with international instruments.
- 16.5.1 Proportion of persons who had at least one contact with a public official and who paid a bribe to a public official, or were asked for a bribe by those public officials, during the previous 12 months.
- 16.5.2 Proportion of businesses that had at least one contact with a public official and that paid a bribe to a public official, or were asked for a bribe by those public officials during the previous 12 months.
- 16.6.1 Primary government expenditures as a proportion of original approved budget, by sector (or by budget codes or similar).
- 16.6.2 Proportion of population satisfied with their last experience of public services.

- 16.7.1 Proportions of positions in national and local institutions, including (a) the legislatures; (b) the public service; and (c) the judiciary, compared to national distributions, by sex, age, persons with disabilities and population groups.
- 16.7.2 Proportion of population who believe decision-making is inclusive and responsive, by sex, age, disability and population group.
- 16.8.1 Proportion of members and voting rights of developing countries in international organisations.
- 16.9.1 Proportion of children under 5 years of age whose births have been registered with a civil authority, by age.
- 16.10.1 Number of verified cases of killing, kidnapping, enforced disappearance, arbitrary detention and torture of journalists, associated media personnel, trade unionists and human rights advocates in the previous 12 months.
- 16.10.2 Number of countries that adopt and implement constitutional, statutory and/or policy guarantees for public access to information.
- 16.a.1 Existence of independent national human rights institutions in compliance with the Paris Principles.
- 16.b.1 Proportion of population reporting having personally felt discriminated against or harassed in the previous 12 months on the basis of a ground of discrimination prohibited under international human rights law.

17 PARTNERSHIPS FOR THE GOALS



GOAL 17: STRENGTHEN THE MEANS OF IMPLEMENTATION AND REVITALIZE THE GLOBAL PARTNERSHIP FOR SUSTAINABLE DEVELOPMENT

TARGETS:

- 17.1 Strengthen domestic resource mobilization, including through international support to developing countries, to improve domestic capacity for tax and other revenue collection.
- 17.2 Developed countries to implement fully their official development assistance commitments, including the commitment by many developed countries to achieve the target of 0.7 per cent of gross national income for official development assistance (ODA/GNI) to developing countries and 0.15 to 0.20 per cent of ODA/GNI to least developed countries; ODA providers are encouraged to consider setting a target to provide at least 0.20 per cent of ODA/GNI to least developed countries.
- 17.3 Mobilize additional financial resources for developing countries from multiple sources.
- 17.4 Assist developing countries in attaining long-term debt sustainability through coordinated policies aimed at fostering debt financing, debt relief and debt restructuring, as appropriate, and address the external debt of highly indebted poor countries to reduce debt distress.
- 17.5 Adopt and implement investment promotion regimes for least developed countries.
- 17.6 Enhance North-South, South-South and triangular regional and international cooperation on and access to science, technology and innovation and enhance knowledge-sharing on mutually agreed terms, including through improved coordination among existing mechanisms, in particular at the United Nations level, and through a global technology facilitation mechanism.
- 17.7 Promote the development, transfer, dissemination and diffusion of environmentally sound technologies to developing countries on favourable terms, including on concessional and preferential terms, as mutually agreed.

- 17.8 Fully operationalise the technology bank and science, technology and innovation capacity-building mechanism for least developed countries by 2017 and enhance the use of enabling technology, in particular information and communications technology.
- 17.9 Enhance international support for implementing effective and targeted capacity-building in developing countries to support national plans to implement all the Sustainable Development Goals, including through North-South, South-South and triangular cooperation.
- 17.10 Promote a universal, rules-based, open, non-discriminatory and equitable multilateral trading system under the World Trade Organisation, including through the conclusion of negotiations under its Doha Development Agenda.
- 17.11 Significantly increase the exports of developing countries, in particular with a view to doubling the least developed countries' share of global exports by 2020.
- 17.12 Realise timely implementation of duty-free and quota-free market access on a lasting basis for all least developed countries, consistent with World Trade Organisation decisions, including by ensuring that preferential rules of origin applicable to imports from least developed countries are transparent and simple, and contribute to facilitating market access.
- 17.13 Enhance global macroeconomic stability, including through policy coordination and policy coherence.
- 17.14 Enhance policy coherence for sustainable development.
- 17.15 Respect each country's policy space and leadership to establish and implement policies for poverty eradication and sustainable development.
- 17.16 Enhance the Global Partnership for Sustainable Development, complemented by multi-stakeholder partnerships that mobilize and share knowledge, expertise, technology and financial resources, to support the achievement of the Sustainable Development Goals in all countries, in particular developing countries.
- 17.17 Encourage and promote effective public, public-private and civil society partnerships, building on the experience and resourcing strategies of partnerships.
- 17.18 By 2020, enhance capacity-building support to developing countries, including for least developed countries and small island developing States, to increase significantly the availability of high-quality, timely and reliable data disaggregated by income, gender, age, race, ethnicity, migratory status, disability, geographic location and other characteristics relevant in national contexts.

17.19 By 2030, build on existing initiatives to develop measurements of progress on sustainable development that complement gross domestic product, and support statistical capacity-building in developing countries.

INDICATORS:

17.1.1 Total government revenue as a proportion of GDP, by source.

17.1.2 Proportion of domestic budget funded by domestic taxes.

17.2.1 Net official development assistance, total and to least developed countries, as a proportion of the Organisation for Economic Cooperation and Development (OECD) Development Assistance Committee donors' gross national income (GNI).

17.3.1 Foreign direct investment, official development assistance and South-South cooperation as a proportion of gross national income.

17.3.2 Volume of remittances (in United States dollars) as a proportion of total GDP.

17.4.1 Debt service as a proportion of exports of goods and services.

17.5.1 Number of countries that adopt and implement investment promotion regimes for developing countries, including the least developed countries.

17.6.1 Fixed Internet broadband subscriptions per 100 inhabitants, by speed.

17.7.1 Total amount of funding for developing countries to promote the development, transfer, dissemination and diffusion of environmentally sound technologies.

17.8.1 Proportion of individuals using the Internet.

17.9.1 Dollar value of financial and technical assistance (including through North-South, South-South and triangular cooperation) committed to developing countries.

17.10.1 Worldwide weighted tariff-average.

17.11.1 Developing countries' and least developed countries' share of global exports.

17.12.1 Weighted average tariffs faced by developing countries, least developed countries and small island developing States.

17.13.1 Macroeconomic Dashboard

17.14.1 Number of countries with mechanisms in place to enhance policy coherence of sustainable development.

17.15.1 Extent of use of country-owned results frameworks and planning tools by providers of development cooperation.

17.16.1 Number of countries reporting progress in multi-stakeholder development effectiveness monitoring frameworks that support the achievement of the Sustainable Development Goals.

- 17.17.1 Amount in United States dollars committed to public-private partnerships for infrastructure.
- 17.18.1 Statistical capacity indicator for Sustainable Development Goal monitoring.
- 17.18.2 Number of countries that have national statistical legislation that complies with the Fundamental Principles of Official Statistics.
- 17.18.3 Number of countries with a national statistical plan that is fully funded and under implementation, by source of funding.
- 17.19.1 Dollar value of all resources made available to strengthen statistical capacity in developing countries.
- 17.19.2 Proportion of countries that (a) have conducted at least one population and housing census in the last 10 years; and (b) have achieved 100 per cent birth registration and 80 per cent death registration.

Appendix 2: Examples of Presentations from the Consultation 3 Breakout Sessions – Addis Ababa, April 2019

Slide 1

Group1 SP1 Notes

- Should the governance include maintenance of the data?
- What is the different between governance model and institutional structures?
- The governance is a high level preposition and should not be at the same level as the other elements.
- It is better to say institutional arraignment or coordination than structures!
- Governance model or Responsibilities and authorities model!
- UNDP's definition of governance should be considered.
- Is the structure of governance showing the details for responsibilities.

Slide 2

Group1 SP2 Notes

- Policie(s) should be more high level and general.
- Licensing is component of Sharing.
- An overarching "Sharing Element".
- How do we insure the security of the sensitive data(high sensitive data, unmaintained,...etc)
- Implementation and accountability to be moved to SP1.

Slide 3

Group1 SP3 Notes

- It is important to make a business case to show benefits.

Slide 4

Group1 SP4 DATA Notes

- The updating of the data(maintenance).
- The sequence (Acquisition, Custodianship and Maintenance)
- Data Sharing and Supply Chain Interlinkages + Data Curation and Delivery (to be combined to one element)
- A 4th element (Data Security)
- Some of the principles are written in a form of an outcome
- Cost reduction instead of Cost avoidance

Slide 5

Group1 SP5 INNOVATION Notes

- *“The objective is to stimulate the use of the latest cost-effective technologies, process improvements and innovations so that governments”* (other contributions like: users, citizens, academia and private sector)
- The geospatial divide instead of The digital divide and more clarification about the digital divide .
- Each nation should be able(have the Enovation) to bey the data to process, analyze and do make services(deal with the data locally) and minimize any dependency on full solution.

Slide 6

Group1 SP6 Standards Notes

- Appropriateness of data and functions.
- Regional or National body where they can be recognize and adopt the international standards.
- Technology interoperability is better to be used instead of “Technical interoperability”
- Consistency is very essential to be mentioned!
- Interoperability of systems (E-Governance).

Slide 7

Group1 SP7 Partnerships Notes

- International and regional and sub-regional collaboration.
- Horizontal and vertical partnership and collaboration should be included in this pathway.
- The equality of a having a partnership with no boundaries and exclusiveness (ino the body of the pathway).

Slide 8

Group1 SP8 Capacity and Education Notes

- The Geospatial science need to be produced in the education at an early step (e.g. intermediate classes)
- In the Awareness Raising element (Advocacy and outreach programs).
- The awareness should be across all sectors and to have no divide(cross sectors).
- Education should not be exclusive for students in school(professional continues education).
- Smart and well prepared educational materials should be available.
- The element of research is very necessary to be motioned.
- Formal education and innovation setting.
- **SP5's Promoting Innovation Creativity could be replaced with SP8's Entrepreneurship**

Slide 9

Group1 SP9 Communication and Engagement Notes

- We received different versions of the SP9' section!
- ~~Including the general community~~
- Using an appropriate communication channels.
- Replace **Planning Execution** with **Communication Strategies**.
- Monitoring and Evaluation should be **SP!**(or in every SP)(or expand it to have more privilege to cover the other 8SPs).

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GROUP 2

STREAM II - TECHNOLOGY:

SP4 Data, SP5 Innovation & SP6 Standards

SWOT Analysis

Slide 11

SP4 DATA

- 1) Metadata - Most data in Africa do not have metadata.
 - a) Resolved - Need data and metadata especially as fundamental data sets
 - b) Recommendation - Add metadata in description of fundamental data sets
- 2) Data integration and data value chain. How do you manage this especially at the secondary data level?
- 3) Data Maintenance & Management:
 - a) Suggestion – Need enough attention to be given to data maintenance and management.
 - b) Consider relationships, different techniques and approaches in **data maintenance and management**.
 - c) Consider data redundancy and completeness; In addition to supply chain, accuracy of data, quality, data theme and coverage.

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SP4 Data cont/d

3) Data Planning:

Suggestion - Add, where appropriate, an effort to engage as many data providers as possible especially when there is change of data theme and data use e.g. drones for data capture.

4) Data Custodianship Principle – data providers and data users;

a) Data management with respect to availability of data, accuracy, quality and coverage.

b) Observed: Custodianship driven by data user requirements;

c) Recommendation: Make people aware of data and Interoperability - see SP9
Communication & Engagement

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SP5 INNOVATION

1) Technology Advancement is both a threat and an opportunity to enable consideration of other alternatives.

2) What's meant by creativity and innovation? We need to look for an African answer to the problem – should not replicate everything.

3) Anything missing? Stress the need to adapt technology and develop capacity to adapt it as innovation includes adaption of the modern technology

4) **Observation: Innovation is cross cutting**, say in governance and institutions e.g. aligning finance to innovation - Finance for say purchase of software and equipment for data capturing: align data and services that is critical to the nation: collaboration ALL

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SP6 STANDARDS

1) Technical technology interoperability mismatch includes people themselves not just machine

Recommendation: To ensure that on semantics, it is not just machine to machine but also people to people.

2) Noted that some standards are difficult to understand and know when to apply them WEAKNESS

3) Observed - Countries are trying to create own standards including for metadata – efforts going on now from ISO perspective

Recommendation: Encourage each country to use existing standards if they are available.

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SP6 Standards Cont/d

4) Noted that Geographical Names is one of the Fundamental Data sets and every country has rules on Geographical names – the national gazetteers.

5) Suggestion – It is important for location addresses to have the geographical names.

Recommendation: Ensure national standards bodies are recognized and Geospatial institutions need to create partnerships with them.

6) Suggestion: document reference be made to TC 211?

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GROUP 2

STREAM III – PEOPLE:

**SP7 Partnership, SP8 Capacity & Education and
SP9 Communication & Engagement**

SWOT Analysis

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SP7 PARTNERSHIPS

1) Meaning of term industry - The term 'industry' is not clear or understood in the same way in different countries.

2) Joint venture arrangements: Consider cross-sector and interdisciplinary partnership arrangements - participation of community stakeholders is necessary

3) Community engagement is important because it is difficult for it to accept if not engaged; It is to be noted that the community can influence the politicians

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SP7 Partnerships cont/d

3) Horizontal vs vertical?

- a) Noted that while the pathway seems to handle horizontal contribution, it is not clear on vertical inclusion on leadership hierarchy for supporting Geospatial industry.
- b) Missing - Intergovernmental as well as different levels of government partnership is missing
- c) **Suggestion:** Need to include contribution of policy makers as part of partnerships in hierarchical order say, at both parliament and local government levels.

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SP8 CAPACITY & EDUCATION

- 1) Missing: knowledge management including knowledge retention and transfer not clear
- 2) Highlight partnership on knowledge sharing and capacity building.
- 3) Document does appear to refer to establishment of professional bodies and registration.
- 4) Research is missing and it should be part of SP No. 8 on capacity and education.

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SP9 COMMUNICATION & ENGAGEMENT

1) Discussions & Suggestions:

- a) Stakeholder identification is limited to identifying stakeholders only So, update the box to Stakeholder Identification and user/stakeholder engagement;
- b) Combine Integrated Engagement Strategies from the old SP9 with Strategic Engagement in the new SP9;
- c) New box Methods of communication that combines three boxes from the updated SP9 into one; Strategic communications, Media and campaigns and Internal communications;
- d) Retain the box for Monitoring and evaluation;

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SP9 Communication & Engagement Cont/d

Recommendation: That is, SP9 should have the following four (4) boxes: -

- Box 1 Stakeholder identification and user engagement,
- Box 2 Integrated engagement strategies and strategic engagement,
- Box 3 Methods of communication and
- Box 4 Monitoring and evaluation

2) Replace reference to 'awareness' with the term 'advocacy'

2) Capture feedback of partners

Appendix 3: Development Account – 11th Tranche Project

Introduction

The Development Account Project 1819D “Strengthening geospatial information management in developing countries towards implementing the 2030 Agenda” focusses on improving and strengthening national geospatial information management and capacities in six target countries (Burkina Faso, Ethiopia, Fiji, Mongolia, Nepal and Kingdom of Tonga).

Initiated in 2018, this Development Account Project leverages the Integrated Geospatial Information Framework (IGIF) adopted by the United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM) at its eighth session in August 2018 (E/2018/46, Decision 8/113) as the overarching strategic framework for strengthening national geospatial information management. The IGIF provides a basis, a reference and a mechanism for Member States when developing and strengthening their national and sub-national arrangements in geospatial information management, related infrastructures and capacities. The Framework translates high-level concepts to practical implementation guidance for use by Member States and does this by leveraging seven underpinning principles, eight goals and nine strategic pathways. The nine strategic pathways guide governments towards implementing integrated geospatial information arrangements in a way that will deliver a vision for sustainable social, environmental and economic development.

The implementation of this Development Account Project has been designed with reference to globally agreed frameworks and guides as a way to build good practise geospatial information management capabilities within the six target countries. The capacity development activities are aligned with the vision, principles, goals and strategic pathways espoused in the Integrated Geospatial Information Framework Part 1: Overarching Strategic Framework. These capacity development activities are also designed with consideration to the Implementation Guide (Part 2) of the Framework that is being developed. The Framework’s Implementation Guide will provide specific guidance for accomplishing the recommended Development Account Project activities including developing the Country-level Action Plan for strengthening national geospatial information management.

At the same time, the capacity development activities are designed to recognise national circumstances by recognising that one size does not fit all. The activities are adaptable and designed to draw out and work with national strategic and development priorities.

In addition, the key underpinning principle for each capacity development activity is that each country will own, design, direct, implement, manage and sustain their own Integrated Geospatial Information Management Strategy and Action Plan. This approach is innovative because it recognises existing capacities and delivers transformation through the strengthening of these existing capacities.

Capacity development for a project of this nature would typically employ a foreign expert to work with a Ministry to undertake analysis and develop the Country-level Action Plans. While there is transfer of some knowledge from the expert to Ministry, the approach does not favour sustainable change.

The Development Account Project takes a more inclusive approach, and one where institutional capacity and capability development commences with the very first activity, and gradually matures as each successive activity is undertaken. While the consultant provides a crucial role in the capacity development process; actual capacity is locally generated and sustained.

Significance of the Development Account Project

Geospatial information, such as maps, satellite imagery and aerial photography, describes the connection between a place, its people and their activities. It illustrates what is happening - where, how and why, and can be used to examine what has happened in the past, and to create likely future scenarios.

Geospatial information is collected and managed through a variety of sensors and platforms including satellites, aircrafts, unmanned aerial systems, terrestrial, handheld, boats and submersibles, etc. The data collected or captured reflects the physical world in which all human, environmental and economic activities takes place. The geographic features collected and collated over 3-dimensional space and time. It is also used to visualise the dynamics of the environment (4-dimensional space) as a series of maps of the same area captured over time. In many nations, there is a steady increase in the number of government departments, businesses and academic organisations that collect geospatial information, and decision makers are increasingly recognising the opportunities afforded through the ability to harness this information for evidenced-based policy setting, and integrated and transparent government services.

However, geospatial information is often not well integrated across the broader government sector, nor in a format that can be easily used for analysis. This limits decision-making capabilities and capacity. In addition, access to geospatial information in developing countries is often inadequate as there is no underlying culture of sharing information and institutional

barriers exist. Information is typically fragmented across a number of institutions and this compounds the ability to agree on and implement common policies and standards across the country.

As a consequence, there is a need to significantly support countries to work towards national integrated geospatial information management systems through the formulation of appropriate frameworks, guidelines and methodologies that can be piloted and implemented within and across countries and regions.

To this end, the UN Secretariat is implementing this Development Account Project to strengthen arrangements in national geospatial information management in developing countries. This is important. The 2030 Agenda for Sustainable Development unequivocally call for coordinated actions in new data acquisition and integration approaches, to ensure the availability and accessibility of quality, timely and reliable geospatial information.

The Development Account Project provides the opportunity for the geospatial community to meet this unprecedented need for more data covering all aspects of sustainable development. The capacity development activities developed for this Project support the development of the necessary geospatial information arrangements (data, technology, governance, financial, legal and policy, partnerships, education) to guide the way countries collectively manage and transform their social, economic and environmental dimensions for the betterment of people, planet, peace and prosperity. It is therefore highly transformative and a significant step towards achieving the 2030 Agenda for Sustainable Development.

Appendix 4: Current and Desired Performance Survey - Ethiopia

PURPOSE:

The Current and Desired Performance Survey was used to collect information regarding both the current and desired performance of the Ethiopian Geospatial Information Institute (EGII), thereby providing clear data regarding the size, direction, and relative priority of performance gaps (or needs) against each of the eight Goals of the Strategic Framework (Chapter 7, Table 7.2).

As described in Chapter 7 (section 7.3.4), the progressive achievement of the Goals will move countries towards a future state where they have the capacity and skills to organise, manage, curate and leverage geospatial information to advance government policy and decision-making capabilities, bridge the geospatial digital divide, influence inclusive and transformative societal change, achieve economic prosperity and social development, and ensure effective environmental management. Each country will have different priorities for each Goal depending on their current situation and context.

The Current and Desired Performance Survey considers EGII's:

- **Current Performance** in terms of the extent of progress towards achieving the Goals; and
- **Desired Performance** in terms of national priorities.

The Survey was designed to stimulate a discussion about the key issues related to geospatial information management in order to build a common understanding among EGII.

METHOD:

The survey was completed in a group setting in July 2019 by a project team of senior managers. Workshop discussions were convened on 18, 19 and 22 July 2019.

Chairperson: Belachew Tsehay

Minutes: Slehak Melak

Stakeholders: Berihu Alemayehu; Dereje Mekonnen; Habtamu Sewunet; Eyasu Lema; Tsegaye Ayele; and Firesew Feyso.

The method guidance was as follows:

1. Set up a meeting to discuss the survey with the whole project team. If possible, invite a few stakeholders that represent the user community.
2. Work through each survey question in turn.
3. Appoint a scribe to take notes during the discussion.

4. At the end of the meeting, summarise the main discussion points and add these points to the comments section under each question. It is important to document these comments as you may revisit the record of these discussions in the future.

Note: The Survey can also be used to collect information from a much larger number of people. The project team may wish to send this survey to additional stakeholders to get their perspectives on the current situation and future priorities.

GOAL 1: Effective Geospatial Information Management		
Enabling geospatial information governance, policy and institutional arrangements that ensure effective geospatial information management, accommodate individual organisational requirements and arrangements, and that are aligned to national and regional priorities, and global policy frameworks.		
Current Performance <u>Progress</u> 1 = Not started; 2 = Minimal; 3 = Moderate; 4 = Extensive; 5 = Achieved	Statement	Desired Performance <u>Priority</u> 1 = Low and 5 = High
① ② ③ ④ ⑤	The extent to which our governance arrangements for geospatial information management bring together a broad range of institutions to share and provide access to data.	① ② ③ ④ ⑤
Comment: Current performance - GII is mandated to coordinate national geospatial information management. - National spatial information and technology policy is enacted. - National open data policy is enacted. - The existing policy frameworks lack alignment and are not implemented yet. There is also lack of awareness on the policy frameworks throughout the industry spectrum. Desired Performance - Establishing governance arrangements to bring together institutions to share provide access to their data is the most fundamental initiative and must be given the highest priority and utmost urgency.		
Current Performance <u>Progress</u> 1 = Not started; 2 = Minimal; 3 = Moderate; 4 = Extensive; 5 = Achieved	Statement	Desired Performance <u>Priority</u> 1 = Low and 5 = High
① ② ③ ④ ⑤	The extent to which our geospatial policies and laws stimulate data sharing, innovation and use of geospatial information.	① ② ③ ④ ⑤

Comment: Current performance - The existing policy frameworks lack alignment and are not implemented yet. - There is also lack of awareness on the policy frameworks throughout the industry spectrum. - There is no data sharing culture in the country which led to the low level of geospatial information and technology usage. - Innovation in the area if geospatial technology area is at its lower stage in the country. Desired Performance - Developing complementary policy frameworks and creating awareness is one of the most fundamental initiatives and must be given the highest priority and utmost urgency.		
Current Performance <u>Progress</u> 1 = Not started; 2 = Minimal; 3 = Moderate; 4 = Extensive; 5 = Achieved	Statement The extent to which our technologies and processes enable geospatial information to be easily shared with the broader community of users.	Desired Performance <u>Priority</u> 1 = Low and 5 = High
① ② ③ ④ ⑤		① ② ③ ④ ⑤
Comment: Current performance - Little technology platforms are in place for information sharing. - Information sharing processes across the industry are ad hoc. Desired Performance - Can be solved easily once all governance arrangements and policy frameworks are in place and therefore moderate priority is sufficient.		

GOAL 2: Increased Capacity, Capability, and Knowledge Transfer Mechanisms are established to raise awareness of the value and use of geospatial information, promote capacity and capability, and build an inventive and resourceful mindset across government, industry, academia, and the private and community sectors.		
Current Performance <u>Progress</u> 1 = Not started; 2 = Minimal; 3 = Moderate; 4 = Extensive; 5 = Achieved	Statement The extent to which our government encourages business development and research through Innovation Programs, Open Data hubs, code-sprints and incentivised business start-up initiatives.	Desired Performance <u>Priority</u> 1 = Low and 5 = High
① ② ③ ④ ⑤		① ② ③ ④ ⑤
Comment: Current performance - Initiatives are underway to establish technology incubation networks. - National innovation strategy is in place.		

- National digital industry policy is in place. Desired Performance - It is important to focus on the establishment of geospatial technology centres of excellence and innovation networks.		
Current Performance <u>Progress</u> 1 = Not started; 2 = Minimal; 3 = Moderate; 4 = Extensive; 5 = Achieved	Statement The extent to which our institutions have the capacity and capability to take advantage of geospatial information resources to build new and innovative products and services.	Desired Performance <u>Priority</u> 1 = Low and 5 = High
① ② ③ ④ ⑤		① ② ③ ④ ⑤
Comment: Current performance - Private and public sector institutions are starting to use online platforms and advanced techniques to develop solutions. - Education and research institutions are providing Bsc. and Msc. level degrees in the fields of geospatial sciences. Desired Performance - The curriculum in universities and training institutions shall be updated regularly to fit the fast changing technology spectrum.		
Current Performance <u>Progress</u> 1 = Not started; 2 = Minimal; 3 = Moderate; 4 = Extensive; 5 = Achieved	Statement The extent to which government regularly promotes the use and value of geospatial information.	Desired Performance <u>Priority</u> 1 = Low and 5 = High
① ② ③ ④ ⑤		① ② ③ ④ ⑤
Comment: Current performance - There has not been any promotions from the government regarding the use and value of geospatial information that we can recall. - Most government organisations do not even consider to include geospatial information in their decision making processes. Desired Performance - The government officials at the highest levels of offices must advocate the value of geospatial information to the overall economic development of the nation.		

GOAL 3: Integrated Geospatial Information Systems and Services

Geospatial information, including community information, is integrated and accessible as a national information system-of-systems and services across the government sector and maximised for evidence-based policy and decision-making. The Integrated Geospatial Information Systems Framework, anchored by the NSDI, facilitates these processes.

Current Performance <u>Progress</u> 1 = Not started; 2 = Minimal; 3 = Moderate; 4 = Extensive; 5 = Achieved	Statement The extent to which our geospatial information is easy to find, view and use.	Desired Performance <u>Priority</u> 1 = Low and 5 = High
① ② ③ ④ ⑤		① ② ③ ④ ⑤
Comment: Current performance • Data is available in organisational silos. • The available data is difficult to access as it is found in the hands of individuals that is there are little central repositories in most organisations. • Almost all the data suffers from the lack of metadata. Desired Performance • Can be solved once all governance arrangements, policy frameworks, metadata and content standards are in place.		
Current Performance <u>Progress</u> 1 = Not started; 2 = Minimal; 3 = Moderate; 4 = Extensive; 5 = Achieved	Statement The extent to which our local community readily contributes geospatial information (e.g. through crowdsourcing or through data managed at the local level) to enhance national government data sources.	Desired Performance <u>Priority</u> 1 = Low and 5 = High
① ② ③ ④ ⑤		① ② ③ ④ ⑤
Comment: Current performance • No one is contributing to enhance national government data sources. • There is no suitable condition for individuals or groups to contribute to national data sources. • There is a fear in data security. Desired Performance • Can be possible when national repositories are defined and put in place and awareness is created.		
Current Performance <u>Progress</u> 1 = Not started; 2 = Minimal; 3 = Moderate; 4 = Extensive; 5 = Achieved	Statement The extent to which our geospatial data is able to be used to analyse complex relationships, trends and patterns across a broad spectrum of applications.	Desired Performance <u>Priority</u> 1 = Low and 5 = High
① ② ③ ④ ⑤		① ② ③ ④ ⑤

Comment:

Current performance

- The data available in organisational silos contains basic attributes to make base maps and thematic maps.
- The national data-sets lack the necessary diversity to analyse complex relationships.

Desired Performance

- Developing integrated geospatial information management and sharing frameworks is believed to solve the situation.

GOAL 4: Economic Return on Investment

An economic return on investment, and other often intangible socio-economic benefits, is realised through best practice management, and the exploitation and innovative use of integrated geospatial information. Provides a means to account for the costs associated with all aspects of a national geospatial information program and the socio-economic value and realised benefits that result from these costs and investment.

Current Performance <u>Progress</u> 1 = Not started; 2 = Minimal; 3 = Moderate; 4 = Extensive; 5 = Achieved	Statement	Desired Performance <u>Priority</u> 1 = Low and 5 = High
① ② ③ ④ ⑤	The extent to which government financing of geospatial information management is clearly showing, through specific case studies, a direct and indirect economic return investment.	① ② ③ ④ ⑤

Comment:

Current performance

- There is no study that shows the economic return on investment.

Desired Performance

- The economic return on investment shall be assessed at least every two years.

Current Performance <u>Progress</u> 1 = Not started; 2 = Minimal; 3 = Moderate; 4 = Extensive; 5 = Achieved	Statement	Desired Performance <u>Priority</u> 1 = Low and 5 = High
① ② ③ ④ ⑤	The extent to which new business ventures have evolved as a consequence of having access to government geospatial information.	① ② ③ ④ ⑤

Comment:

Current performance

- There is no formal study or report to indicate the evolution of new business venture as a consequence of geospatial data access.

Desired Performance

- Data must be made easily accessible via a single central hub.
- Return on economic investment shall be studied together with the return on investment assessment.

Current Performance <u>Progress</u> 1 = Not started; 2 = Minimal; 3 = Moderate; 4 = Extensive; 5 = Achieved	Statement The extent to which our geospatial information is contributing to economic growth across a range of industry sectors.	Desired Performance <u>Priority</u> 1 = Low and 5 = High
① ② ③ ④ ⑤		① ② ③ ④ ⑤
Comment: Current performance - Data is being used in land administration, infrastructure development, and natural resource management. - Coverage of the economic sectors is limited. Desired Performance - Continuous promotion and awareness creation initiatives must be undertaken.		

GOAL 5: Sustainable Education and Training Programs Education and training programs are established to grow the number if professionals in the fields of geography, data science and geospatial information technology, and to develop specialist skills related to geospatial financial systems, policy and law, and project management.		
Current Performance <u>Progress</u> 1 = Not started; 2 = Minimal; 3 = Moderate; 4 = Extensive; 5 = Achieved	Statement The extent to which our institutions have the capacity and professional expertise to strengthen geospatial information management.	Desired Performance <u>Priority</u> 1 = Low and 5 = High
① ② ③ ④ ⑤		① ② ③ ④ ⑤
Comment: Current performance - Education and research institutions are providing Bsc. and Msc. level degrees in the fields of geospatial sciences. Desired Performance - The curriculum in universities shall be updated regularly to fit the fast changing technology spectrum.		
Current Performance <u>Progress</u> 1 = Not started; 2 = Minimal; 3 = Moderate; 4 = Extensive; 5 = Achieved	Statement The extent to which our geospatial professionals have access to, and an	Desired Performance <u>Priority</u> 1 = Low and 5 = High

① ② ③ ④ ⑤	understanding of, advanced technologies and methods.	① ② ③ ④ ⑤
Comment: Current performance - The Education in universities lack regular reviews and updates. - Most of the courses focus on theories with little focus on skills. Desired Performance - The curriculum in universities shall be updated to include advances in technologies and methods.		
Current Performance <u>Progress</u> 1 = Not started; 2 = Minimal; 3 = Moderate; 4 = Extensive; 5 = Achieved	Statement The extent to which our education and training system provides curricula in the fields of geography, geospatial science, surveying and geodesy.	Desired Performance <u>Priority</u> 1 = Low and 5 = High
① ② ③ ④ ⑤		① ② ③ ④ ⑤
Comment: Current performance - Educational and training institutions providing short courses, Bsc. and Msc. training. - The common fields of study include GIS and RS, surveying, geomatics engineering, and geo-informatics. Desired Performance - Regular syllabus update is necessary.		

GOAL 6: International Cooperation and Partnerships Leveraged

International cooperation and partnerships are leveraged and sustained in a way that fosters the management and exchange of geospatial information in support of national development interests. For developing countries, these mechanisms increase development capacity, enhance organisational knowledge and collaboration, and empower creativity and innovation.

Current Performance <u>Progress</u> 1 = Not started; 2 = Minimal; 3 = Moderate; 4 = Extensive; 5 = Achieved	Statement The extent to which our geospatial information management is characterised by bilateral/multilateral cooperation with other organisations and countries.	Desired Performance <u>Priority</u> 1 = Low and 5 = High
① ② ③ ④ ⑤		① ② ③ ④ ⑤
Comment: Current performance - There are some bi-lateral cooperation arrangements for specific areas. - Limited multi-lateral cooperation. Desired Performance		

- Working with some more partners would help, but the most important thing is developing national capability first and foremost.

Current Performance <u>Progress</u> 1 = Not started; 2 = Minimal; 3 = Moderate; 4 = Extensive; 5 = Achieved	Statement	Desired Performance <u>Priority</u> 1 = Low and 5 = High
	The extent to which our geospatial information management frameworks support international cooperation and partnerships.	
① ② ③ ④ ⑤		① ② ③ ④ ⑤

Comment:

Current performance

- We lack national geospatial information management frameworks.
- Having National Spatial Information and technology Policy.

Desired Performance

- Developing internationally compatible geospatial information management frameworks is utmost urgency.

Current Performance <u>Progress</u> 1 = Not started; 2 = Minimal; 3 = Moderate; 4 = Extensive; 5 = Achieved	Statement	Desired Performance <u>Priority</u> 1 = Low and 5 = High
	The extent to which our Nation is recognised internationally as a trusted partner for geospatial information related projects and initiatives.	
① ② ③ ④ ⑤		① ② ③ ④ ⑤

Comment:

Current performance

- We have been working and continue to work with international partners in areas of land management.
- Our institution, GII, recognised in the Geospatial World Forum for its services.

Desired Performance

- Advancing our national capabilities is very important.

GOAL 7: Enhanced National Engagement and Communication

All stakeholder groups, and specifically high-level decision-makers and champions, understand and are fully engaged in the value of integrated geospatial information for decision-making and socio-economic development. This creates a greater sense of trust in geospatial information, and in the organisations that provide it.

Current Performance <u>Progress</u> 1 = Not started; 2 = Minimal;	Statement	Desired Performance <u>Priority</u> 1 = Low and 5 = High

3 = Moderate; 4 = Extensive; 5 = Achieved	The extent to which our stakeholders are supporting our strategic journey for strengthening geospatial information management and use.	
① ② ③ ④ ⑤		① ② ③ ④ ⑤
Comment: Current performance - Mandate redundancy and problems. - Poor awareness and supporting strategies. Desired Performance - Should be a national priority.		
Current Performance <u>Progress</u> 1 = Not started; 2 = Minimal; 3 = Moderate; 4 = Extensive; 5 = Achieved	Statement The extent to which there is a heightened awareness of the benefits and value of geospatial information at all levels of government.	Desired Performance <u>Priority</u> 1 = Low and 5 = High
① ② ③ ④ ⑤		① ② ③ ④ ⑤
Comment: Current performance - Little or no awareness at the top. Desired Performance - This is a must have for the advancement of the industry.		
Current Performance <u>Progress</u> 1 = Not started; 2 = Minimal; 3 = Moderate; 4 = Extensive; 5 = Achieved	Statement The extent to which our stakeholder communication and engagement plan is proving effective in raising the awareness of the value of geospatial information.	Desired Performance <u>Priority</u> 1 = Low and 5 = High
① ② ③ ④ ⑤		① ② ③ ④ ⑤
Comment: Current performance - There is an engagement strategy in the major governmental organisations working in geospatial area to create awareness in the value of geospatial information. Desired Performance - Can be addressed with a moderate priority.		

GOAL 8: Enriched Societal Value and Benefits

Social and development, and environmental sustainability, is enriched through increased levels of use of integrated geospatial information products and services. Drivers demonstrating the value and benefits of geospatial information include the global development Agendas, transforming government, community expectations, and bridging the geospatial digital divide.

Current Performance <u>Progress</u> 1 = Not started; 2 = Minimal; 3 = Moderate; 4 = Extensive; 5 = Achieved	Statement	Desired Performance <u>Priority</u> 1 = Low and 5 = High
① ② ③ ④ ⑤	The extent to which geospatial information is being used effectively to save lives e.g. emergency preparedness, response and recovery.	① ② ③ ④ ⑤
Comment: Current performance - Emergency management organisations use geospatial information for planning and execution of emergency response. Desired Performance - It must be given the highest priority as the country has volatile ethnic conflicts. The risks shall be analysed and mitigated prior to the incidents.		
Current Performance <u>Progress</u> 1 = Not started; 2 = Minimal; 3 = Moderate; 4 = Extensive; 5 = Achieved	Statement	Desired Performance <u>Priority</u> 1 = Low and 5 = High
① ② ③ ④ ⑤	The extent to which citizens are benefitting from the use of geospatial information for improved urban planning and infrastructure development i.e. improved lifestyles through better access to utilities and services.	① ② ③ ④ ⑤
Comment: Current performance - The country at large is still at the beginning stage of geospatial information usage for planning and decision making. - Urban planning and infrastructure development are not as such based on spatial analysis and spatial planning. Desired Performance - All decisions in areas of utility, services, urban planning and management must be made using geospatial information.		
Current Performance <u>Progress</u> 1 = Not started; 2 = Minimal; 3 = Moderate; 4 = Extensive; 5 = Achieved	Statement	Desired Performance <u>Priority</u> 1 = Low and 5 = High
	The extent to which geospatial information is integrated with statistical	

① ② ③ ④ ⑤	data to monitor and evaluate progress towards the SDGs.	① ② ③ ④ ⑤
Comment: Current performance - Initiatives done on exercising SDGs from some government organisations. Desired Performance - Integration of SDG performance statistics and geospatial information must be given high priority as the spatial extent/coverage of achievement is depicted better using thematic maps.		

Appendix 5: Baseline Survey – Ethiopia

PURPOSE:

The Baseline Survey was used to gather detailed information about the current geospatial information management ecosystem in the Ethiopian Geospatial Information Institute (EGII), thereby providing an important input into the Needs Assessment and Gap Analysis in Chapter 8, as it helped to understand gaps in current capabilities.

The questions were categorised according to the nine Strategic Pathways defined in the Strategic Framework. Because the Baseline Survey captures a particular point in time, it can be used to measure progress by conducting the survey again in the future.

METHOD:

The Baseline Survey was designed to be best performed by a delegated person/s tasked with gathering the information to answer the questions from subject matter experts. This would ensure consistency in the interpretation of the questions, particularly for the questions regarding the various datasets.

The suggested method was as follows:

Set up a meeting with subject matter experts to discuss and document the answers to the survey questions.

Work through each survey question in turn.

Where questions were not clear – document the discussion and likely answers for clarification.

Workshop discussions were convened from 23 – 25 July 2019.

Chairperson: Belachew Tsehay

Minutes: Slehak Melak

Stakeholders: Berihu Alemayehu; Dereje Mekonnen; Habtamu Sewunet; Eyasu Lema; Tsegaye Ayele; and Firesew Feyso.

Strategic Pathway 1: Governance and Institutions

The following questions are designed to understand the governance and institutional arrangements, and political buy-in for integrated geospatial information management.

1	Do you have a National Geospatial Strategy or equivalent? ☐ Yes Name: _____ (Go to Question 2) ☒ No There are beginnings of NSDI roadmaps and strategies, but not finalised. If No, which of the following applies? ☒ Too time-consuming and there are no resources to develop the strategy ☒ Training in strategy development is required ☐ It is believed a strategy is not required ☐ Other: • Poor attention from the concerned stakeholders • Poor political will and lack of awareness from higher officials • Lack of commitment from concerned institutions																														
2	Has the National Geospatial Strategy or equivalent been endorsed at a high level? ☐ Yes. If yes, what is the level of endorsement? ☐ Reviewed and approved by organisation leadership ☐ Reviewed and accepted by the national geospatial coordination body ☐ Aspects included in higher-level organisation's Strategic Plan ☐ Other _____ ☒ No If No, please explain why the strategy has not been endorsed. _____ _____ _____																														
3	Do stakeholders resonate with the strategic vision? <table border="0"> <tr> <td>Government geospatial data suppliers</td><td>☐ Yes</td><td>☒ No</td><td>☐ Some</td><td>☐ Don't know</td></tr> <tr> <td>Government geospatial data users</td><td>☐ Yes</td><td>☒ No</td><td>☐ Some</td><td>☐ Don't know</td></tr> <tr> <td>Businesses</td><td>☐ Yes</td><td>☒ No</td><td>☐ Some</td><td>☐ Don't know</td></tr> <tr> <td>Geospatial Industry</td><td>☐ Yes</td><td>☒ No</td><td>☐ Some</td><td>☐ Don't know</td></tr> <tr> <td>Academic Institutions</td><td>☐ Yes</td><td>☒ No</td><td>☐ Some</td><td>☐ Don't know</td></tr> <tr> <td>Citizens</td><td>☐ Yes</td><td>☒ No</td><td>☐ Some</td><td>☐ Don't know</td></tr> </table>	Government geospatial data suppliers	☐ Yes	☒ No	☐ Some	☐ Don't know	Government geospatial data users	☐ Yes	☒ No	☐ Some	☐ Don't know	Businesses	☐ Yes	☒ No	☐ Some	☐ Don't know	Geospatial Industry	☐ Yes	☒ No	☐ Some	☐ Don't know	Academic Institutions	☐ Yes	☒ No	☐ Some	☐ Don't know	Citizens	☐ Yes	☒ No	☐ Some	☐ Don't know
Government geospatial data suppliers	☐ Yes	☒ No	☐ Some	☐ Don't know																											
Government geospatial data users	☐ Yes	☒ No	☐ Some	☐ Don't know																											
Businesses	☐ Yes	☒ No	☐ Some	☐ Don't know																											
Geospatial Industry	☐ Yes	☒ No	☐ Some	☐ Don't know																											
Academic Institutions	☐ Yes	☒ No	☐ Some	☐ Don't know																											
Citizens	☐ Yes	☒ No	☐ Some	☐ Don't know																											
4	Is the National Geospatial Strategy or equivalent aligned with other government strategic initiatives and agendas?																														

	☐ Yes ☒ No (Go to Question 5) If yes, please send a copy or link to aligned government strategies (or initiatives). <table> <thead> <tr> <th>Strategy Type</th> <th>Strategy Name</th> </tr> </thead> <tbody> <tr><td>☐ Economic Growth</td><td> </td></tr> <tr><td>☐ Poverty Alleviation</td><td> </td></tr> <tr><td>☐ Socially Inclusive Development</td><td> </td></tr> <tr><td>☐ Protection of the Environment</td><td> </td></tr> <tr><td>☐ Water Resource Management</td><td> </td></tr> <tr><td>☐ Disaster Response</td><td> </td></tr> <tr><td>☐ Industry Development</td><td> </td></tr> <tr><td>☐ Agriculture Productivity</td><td> </td></tr> <tr><td>☐ eGovernment</td><td> </td></tr> <tr><td>☐ Sustainable Development Goals</td><td> </td></tr> <tr><td>☐ Other </td><td> </td></tr> <tr><td></td><td> </td></tr> <tr><td></td><td> </td></tr> <tr><td></td><td> </td></tr> <tr><td></td><td> </td></tr> </tbody> </table>	Strategy Type	Strategy Name	☐ Economic Growth		☐ Poverty Alleviation		☐ Socially Inclusive Development		☐ Protection of the Environment		☐ Water Resource Management		☐ Disaster Response		☐ Industry Development		☐ Agriculture Productivity		☐ eGovernment		☐ Sustainable Development Goals		☐ Other									
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4	What are the major drivers of the Geospatial Strategy or equivalent? <i>Select all that apply.</i> ☐ Achieve social, economic and environmental benefits ☐ Need for a coordinated and cost effective approach to geospatial data management ☐ Achieve improved service delivery from a citizens perspective ☐ Need for financial efficiency (e.g. remove data duplication) ☐ Achieve compliance to government requirements ☐ A seamless high quality map to better understanding of nation-wide needs ☐ Other																																

5	Is there a monitoring and evaluation framework associated with the National Geospatial Strategy (or equivalent) used to observe progress towards the achievement of National strategic objectives? ☐ Yes ☒ No (Go to Question 6) If yes, who is responsible for monitoring and evaluation? ☐ Centralised government unit _____ ☐ Responsibility of individual agencies _____ ☐ Other _____ If yes, is there a formal mandate for monitoring and evaluation? ☐ Yes ☐ No
6	What are the major barriers to achieving integrated geospatial information management? <i>Select all that apply.</i> ☒ Poor institutional arrangements and user/provider relationships ☒ Information is not currently in a form that can be easily shared e.g. hard copy, proprietary ☒ There are inconsistencies in the availability and quality of geospatially referenced data ☒ A lack of consistent policies concerning access to, and use of, geospatial data ☒ Incomplete knowledge about the availability and quality of existing geospatial information ☒ Limited skills in the collection, processing, management and use of geospatial information ☒ Lack of skills in the utilisation of online data sharing and distribution technologies ☒ Lack of commitment from key management towards data sharing ☐ Limited computer literacy in user community ☒ Limited technology to accomplish data integration ☒ The nature of the data makes this activity too complicated ☐ Other _____ _____ _____ _____ _____
6	Is there a clearly identifiable individual(s) (Champion) actively promoting integrated geospatial information management? ☐ Yes Position Title: _____ ☒ No (Go to Question 6)

7	Is there a coordinating unit (central office) responsible for cross-government geospatial information sharing? ☒ Yes ☐ No (Go to Question xx) If yes, please provide: Name: <u>Geospatial Information Institute (GII)</u> Level of Government: <u>National Institute</u> Is the Coordinating unit (central office) involved in the following?: ☐ e-Government ☐ Statistics governance ☐ Open Data Policy Does the Coordinating unit (central office) connect to multiple levels of government? ☒ Local ☒ National ☒ Global
8	Are there cross-government working groups or equivalent that are responsible for the following? Data e.g. standards ☒ Yes ☐ No Technology e.g. data integration and dissemination ☐ Yes ☒ No Geospatial Policy Development ☐ Yes ☒ No Stakeholder Engagement e.g. User Forums ☐ Yes ☒ No Capacity Building and Education ☐ Yes ☒ No
9	What type of project management is typical for development projects: ☒ Formal project management e.g. Prince2, PimBoc ☐ Information is not currently in a form that can be easily shared e.g. hard copy, proprietary ☐ There are inconsistencies in the availability and quality of geospatially referenced data

Strategic Pathway 2: Policy and Legal

The following questions are designed to understand the policy and legal framework currently in place to support data sharing and use.

1	Which of the following government policies/legal documents currently exist (in their own right or as part of another policy/legal document). Please indicate if they are effective or need revision. <table border="1"> <thead> <tr> <th>Policy Type</th> <th>Policy Name</th> <th>Effective</th> <th>Revision Required</th> </tr> </thead> <tbody> <tr> <td>☐ Geospatial Data Management</td> <td>_____</td> <td>☐</td> <td>☐</td> </tr> <tr> <td>☐ Geospatial Information Sharing</td> <td>_____</td> <td>☐</td> <td>☒</td> </tr> <tr> <td>☐ Information Technology Use</td> <td>_____</td> <td>☐</td> <td>☒</td> </tr> <tr> <td>☐ Data/Cyber Security</td> <td>_____</td> <td>☐</td> <td>☒</td> </tr> <tr> <td>☐ Information Privacy</td> <td>_____</td> <td>☐</td> <td>☐</td> </tr> <tr> <td>☐ Open Data</td> <td>_____</td> <td>☐</td> <td>☒</td> </tr> <tr> <td>☐ Data Custodianship</td> <td>_____</td> <td>☐</td> <td>☐</td> </tr> <tr> <td>☐ Data Release</td> <td>_____</td> <td>☐</td> <td>☐</td> </tr> <tr> <td>☐ Data Acquisition</td> <td>_____</td> <td>☐</td> <td>☐</td> </tr> <tr> <td>☐ Intellectual Property Rights</td> <td>_____</td> <td>☐</td> <td>☒</td> </tr> <tr> <td>☐ Freedom of Information</td> <td>_____</td> <td>☐</td> <td>☐</td> </tr> <tr> <td>☐ Data Secrecy</td> <td>_____</td> <td>☐</td> <td>☐</td> </tr> <tr> <td>☐ Other _____</td> <td>_____</td> <td></td> <td></td> </tr> <tr> <td></td> <td>_____</td> <td></td> <td></td> </tr> <tr> <td></td> <td>_____</td> <td></td> <td></td> </tr> <tr> <td></td> <td>_____</td> <td></td> <td></td> </tr> </tbody> </table>	Policy Type	Policy Name	Effective	Revision Required	☐ Geospatial Data Management	_____	☐	☐	☐ Geospatial Information Sharing	_____	☐	☒	☐ Information Technology Use	_____	☐	☒	☐ Data/Cyber Security	_____	☐	☒	☐ Information Privacy	_____	☐	☐	☐ Open Data	_____	☐	☒	☐ Data Custodianship	_____	☐	☐	☐ Data Release	_____	☐	☐	☐ Data Acquisition	_____	☐	☐	☐ Intellectual Property Rights	_____	☐	☒	☐ Freedom of Information	_____	☐	☐	☐ Data Secrecy	_____	☐	☐	☐ Other _____	_____				_____				_____				_____		
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2	Is there a central repository for government policy documents? ☐ No (<i>Go to Question 3</i>) ☒ Yes If Yes, does it have the following: ☒ A Policy Register ☐ Communication Strategy ☐ Compliance Auditing ☐ Policy Compliance Measure																																																																				

3	Is there a policy or legal document that encourages or mandates data sharing between government agencies? ☐ No (<i>Go to Question 4</i>) ☒ Yes. Document Title: • <u>National Spatial Information and Technology Policy ;</u> • <u>Open data policy;</u> • <u>ICT Policy;</u> • <u>Innovation,</u> • <u>Space science policy</u>
4	Is the policy/legal document utilised and well supported by government agencies? ☐ Yes (<i>Go to Question 5</i>) ☒ No If No, which of the following reasons best explain why the policy is unsupported. Please number from 1 to 9, where 1 is the most likely reason and 9 the least reason for lack of compliance. ☒ Purpose of the data sharing policy is unclear (7) ☒ Limited level of awareness that the data sharing policy exists (3) ☒ There are no processes within organisation to enable compliance with data sharing policy (4) ☒ There is no technology in place to enable compliance with data sharing policy (5) ☒ Organisation culture does not support data sharing (2) ☒ Lack of skills in the utilisation of online data sharing and distribution technologies (6) ☒ Lack of commitment from key management towards data sharing (1) ☒ Limited computer literacy in user community (8) ☐ Other _____ _____ _____ _____
5	Do you have a Licensing and Pricing Framework? ☒ No (<i>Go to Question 6</i>) ☐ Yes Name: _____

6	Is there a National classification system under which data is to be released? For example Public Access, Restricted Access and Confidential. ☐ Yes ☒ No (Go to Question 6) If yes, do organisations comply with the classification system? _____
7	Does the government have a National Open Data Policy? ☒ Yes ☐ No (Go to Question 8) If yes, what percentage of government data sets are available in the public domain? _____ ☐ All (100%) ☐ Most (75%) ☐ Half ☐ Some (30%) ☒ Few (less than 15%) ☐ None
8	Do organisations typically use a Pricing Model that specifies fees and charges for data? ☐ Yes ☒ No If yes, which of the following pricing categories may apply? _____ ☐ Free ☐ Cost Recovery (where production costs recouped) ☐ Subsidised (where a fee is charged but is less than cost recovery) ☐ Extract and delivery charges only ☐ Freemium (free of charge with a premium for value adding and advanced features) ☐ Other _____

Strategic Pathway 3: Financial

The following questions are designed to understand the financial arrangements, business model and investment needs for integrated geospatial information management.

1	Is there an overall business model for the development, implementation, maintenance and exploitation of the National Geospatial Information Management framework? ☒ No (Go to Question 2) ☐ Yes, Document Title: _____																																																																																			
2	Is there a clear understanding by decision-makers of the societal and economic benefits of geospatial data? ☒ No ☐ Yes																																																																																			
3	Which sectors are most positively affected now, and which sectors could see significant growth as a consequence of using geospatial data? <table border="1"> <thead> <tr> <th>Sector</th> <th>Considerable Growth</th> <th>Some Growth</th> <th>Potential Growth</th> </tr> </thead> <tbody> <tr> <td>Environment Protection</td> <td>☐</td> <td>☒</td> <td>☐</td> </tr> <tr> <td>Transportation</td> <td>☐</td> <td>☒</td> <td>☐</td> </tr> <tr> <td>Agriculture and Farming</td> <td>☐</td> <td>☒</td> <td>☐</td> </tr> <tr> <td>Aquiculture</td> <td>☐</td> <td>☒</td> <td>☐</td> </tr> <tr> <td>Health</td> <td>☐</td> <td>☒</td> <td>☐</td> </tr> <tr> <td>Biosecurity</td> <td>☐</td> <td>☐</td> <td>☐</td> </tr> <tr> <td>Urban Development Planning</td> <td>☒</td> <td>☐</td> <td>☐</td> </tr> <tr> <td>Community Services</td> <td>☐</td> <td>☐</td> <td>☒</td> </tr> <tr> <td>Emergency Response</td> <td>☐</td> <td>☒</td> <td>☐</td> </tr> <tr> <td>Disaster Preparedness</td> <td>☐</td> <td>☒</td> <td>☐</td> </tr> <tr> <td>Location-based Services</td> <td>☐</td> <td>☒</td> <td>☐</td> </tr> <tr> <td>Mining and Minerals</td> <td>☐</td> <td>☒</td> <td>☐</td> </tr> <tr> <td>Utilities (water, electricity, telecom etc)</td> <td>☐</td> <td>☐</td> <td>☒</td> </tr> <tr> <td>Natural Resource Monitoring</td> <td>☒</td> <td>☐</td> <td>☐</td> </tr> <tr> <td>Research and Innovation</td> <td>☐</td> <td>☐</td> <td>☒</td> </tr> <tr> <td>Finance, Banking</td> <td>☐</td> <td>☐</td> <td>☒</td> </tr> <tr> <td>Education</td> <td>☐</td> <td>☐</td> <td>☒</td> </tr> <tr> <td>Insurance/Risk Management</td> <td>☐</td> <td>☐</td> <td>☒</td> </tr> <tr> <td>Other _____</td> <td>☐</td> <td>☐</td> <td>☐</td> </tr> </tbody> </table>				Sector	Considerable Growth	Some Growth	Potential Growth	Environment Protection	☐	☒	☐	Transportation	☐	☒	☐	Agriculture and Farming	☐	☒	☐	Aquiculture	☐	☒	☐	Health	☐	☒	☐	Biosecurity	☐	☐	☐	Urban Development Planning	☒	☐	☐	Community Services	☐	☐	☒	Emergency Response	☐	☒	☐	Disaster Preparedness	☐	☒	☐	Location-based Services	☐	☒	☐	Mining and Minerals	☐	☒	☐	Utilities (water, electricity, telecom etc)	☐	☐	☒	Natural Resource Monitoring	☒	☐	☐	Research and Innovation	☐	☐	☒	Finance, Banking	☐	☐	☒	Education	☐	☐	☒	Insurance/Risk Management	☐	☐	☒	Other _____	☐	☐	☐
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4	Are there economic sectors or a national projects (such as a census) that could act as a target (or “anchor”) to spearhead economic development as a consequence of reliable geospatial information? ☐ No ☒ Yes • <u>National census</u> • <u>National rural and urban cadaster</u>																																																																																			

	National soil fertility mapping (Go to question 5) _____ _____ _____ _____
5	Is finance secured for development and implementation? ☐ No ☒ Yes _____ Are there opportunities for private sector investment? ☒ No ☐ Yes _____ (Go to Question 6) _____
6	Is finance secured for maintenance (including data maintenance) and exploitation? ☒ No ☐ Yes. If yes for how long? _____ Are there opportunities for private sector involvement in the exploitation e.g. through data contributions, maintenance partnership, in-kind value-adding etc? ☒ No ☐ Yes _____ (Go to Question 7) _____
7	Have financial commitments been signed off at the top level of government? Are they determined in a directive, law or regulation? ☒ No ☐ Yes. If Yes, are they determined in a directive, law or regulation (Go to Question 5) _____ _____
8	Are there opportunities to finance investments through public-private partnerships? ☐ No ☒ Yes _____ (Go to Question 5) _____
9	Are end-users charged for the use of government owned geospatial data or services? ☐ No ☒ Yes. (Go to Question 5) If Yes, is there a clear understanding of the implications of the charging model to end-users? ☒ NO _____
10	Complete the following questions for <u>each organisation</u> that acquires, manages and/or curates geospatial information (Cut and paste table row for each organisation). Name of Organisation: <u>Geospatial Information Institute (GII)</u> Do you have a financial plan for geospatial information management? ☐ No ☒ Yes. _____ Do you have an understanding of the requirements for financing geospatial information and associated activities within your organisation? ☐ No ☒ Yes. _____ Is there a separate budget amount for geospatial information management? or ☐ No ☒ Yes. _____ Are the financial allocations for geospatial information management covered as part of a larger organisational budget? ☐ No ☒ Yes. _____ Do you have an annual budget for costs associated with managing geospatial information? ☐ No ☒ Yes. _____ Do you manage the direct and indirect costs of your geospatial information management program?

☐ No	☒ Yes. _____
To account for the annual cost of inflation, does the budget include an adjustment for inflation?	
☒ No	☐ Yes. _____
Is there a budget for geospatial information operations and maintenance?	
☐ No	☒ Yes. _____
Are contracted support and services included as part of the geospatial information management budget? If so, what is the percentage of contracts within the overall budget?	
☒ No	☐ Yes. Percentage _____
Do you have a way to enumerate the benefits of geospatial information?	
☒ No	☐ Yes. If yes, _____
What is the method you use to indicate the benefits and is data used to back up the claim?	

Is financial information used as part of the benefit claims? _____	
Is there a process for requesting additional (new) funding for new equipment (including computers and software) and/or new initiatives for expanding the capabilities of investing in geospatial information management?	
☒ No	☐ Yes.
What is the source of funding for geospatial information management? (Tick all that apply). Next to each source, please estimate the percentage of each toward your total budget	
☐	Government budget allocation. Percentage _____
☐	Sales from geospatial products. Percentage _____
☐	Donor assistance. Percentage _____
☐	Other _____
Do you have agreements with private companies including contracts for materials and services?	
☒ No	☐ Yes. _____
Do you have agreements with academic institutions that align with the geospatial information management program?	
☒ No	☐ Yes. _____

Strategic Pathway 4: Data

The following questions are designed to understand what data is collected, its quality and how it is currently managed and distributed.

1	Do you have a National Geospatial Data Framework? ☐ Yes ☒ No (Go to Question 2) If Yes, which of the following are part of the Data Framework ☐ A set of fundamental data themes ☐ A set of application data themes ☐ A set of statistical data themes ☐ Data standards ☐ Metadata standards ☐ Mandated data custodians ☐ Data Quality ☐ Data Release Category ☐ Pricing and Licensing Conditions ☐ Other _____
2	Do you have an inventory of government data holdings? ☒ Yes ☐ No (Go to Question 2) If yes, please answer the following: Approximately how many datasets have been inventorised? _____ ~15 How many different organisations contribute data to this inventory? _____ ~10
3	Is there a common single national geodetic datum reference, projection and coordinate system? ☐ Yes ☒ No (Go to Question 3) If yes, please provide more details: Geodetic Datum Used _____ Map Projection _____ Coordinate Systems (e.g. false origin) _____

4	Is positioning data (physical ground survey marks) recorded in spatial database? ☒ Yes ☐ No <i>(Go to Question 5)</i> If yes, does this include historical records? ☒ Yes ☐ No If yes, how is Positioning Data formatted? ☒ Microsoft Excel ☒ GIS database (i.e. Geodatabase, shape file, or similar) ☐ CAD (Computer Aided Design i.e. DXF) ☐ ASCII (American Standard Code for Information Interchange) ☒ CSV (Comma Separated Values) or Text Delineated Format ☐ WMS (Web Map Service) ☐ WFS (Web Feature Service) ☐ WMTS (Web Map Tile Services) ☐ KML (Keyhole Markup Language) ☐ XML (Extensible Markup Language) ☐ Adobe PDF ☐ Other _____
5	Is there a Continually Operating Reference System (CORS) Network? ☒ Yes ☐ No <i>(Go to Question 2)</i> If Yes, what is the format of the data? ☐ RINEX ☒ RTCM ☐ Proprietary format ☐ Other _____ If yes, what is the Financial Model ☐ Open-access (universal free access) ☐ Subsidised* ☐ Cost Recovery ☐ Freemium* * ☐ Full commercial ☒ Other : there is no financial model and the data is not yet functional <i>*Subsidised model – Where a fee is charged but falls under cost recovery</i> <i>**Freemium model - data provided free of charge with a premium charged for value adding, such as advanced features and functionality</i>

6

Do you have a **Geographic Names** dataset?

Yes (nationwide)

☒

Yes (in some areas)

☐

No (text/paper only)

☐

If No, does this apply to a specific
name type only _____

If Yes, please answer the following:

(Go to Question 7)

Which of the following features are collected?

Road Names

☒ Yes

☐ No

Administrative Area Names

☒ Yes

☐ No

Water Body Names

☒ Yes

☐ No

River and Stream Names

☒ Yes

☐ No

Landmark/Monument Name (Place of Interest)

☒ Yes

☐ No

Landform Names (Mountains, Hills, Ranges etc.)

☒ Yes

☐ No

Who is considered the primary data custodian: **GI** _____

Are there duplicate or similar names datasets collected?

☐ Yes

☒ No

If so, who are the secondary data custodians? _____

Is geographic naming a core government function?

☒ Yes

☐ No

Do you have a national geographic names board to approve names?

☐ Yes

☒ No

If yes, does the board participate on the UNGEGN?"

☐ Yes

☐ No

Is the geographic names data accessible?

☐ Yes

☒ No

If yes, how is the data accessed? _____

How often is the data accessed? _____

Who are the primary users? (number 1-5, where 1 is the highest ranked category)

☐ (1)Government ☐ (2)Local Gov. ☐ (4)Utilities ☐ (3) Private Sector ☐ (6)Academia ☐
(5)Community

What is the primary source of geographic names data? (tick all that apply)

☒

Official government source

☐

Crowdsourced

☐

Private Sector

Is geographic names data collected according to a standard?

☐ Yes

☒ No

If yes, what is the standard? _____

What is the accuracy of geographic names data? _____

	Are geographic names linked to a spatial representation?	☒ Yes	☐ No															
7	Do you have a Street Address dataset? ☐ Yes (nationwide) ☒ Yes (in some areas) ☐ No (text/paper only) <i>If No, go to Question 8</i> If Yes, please answer the following: Which of the following features are collected? <table> <tr> <td>House Number</td> <td>☒ Yes</td> <td>☐ No</td> </tr> <tr> <td>Building Name</td> <td>☒ Yes</td> <td>☐ No</td> </tr> <tr> <td>Street Name</td> <td>☒ Yes</td> <td>☐ No</td> </tr> <tr> <td>Locality Name (Parish, Town, City, Suburb etc.)</td> <td>☐ Yes</td> <td>☒ No</td> </tr> <tr> <td>Postcode</td> <td>☐ Yes</td> <td>☒ No</td> </tr> </table> Who is the primary data custodian: <u>City Administrations</u> Are there duplicate or similar address datasets collected? ☐ Yes ☒ No If so, who are the secondary data custodians? _____ Is street addressing a core government function? ☒ Yes ☐ No Is street address data accessible? ☒ Yes ☐ No If yes, how is the data accessed? _____ How often is the data accessed? _____ Who are the primary users? (<i>number 1-5, where 1 is the highest ranked category</i>) ☐ (3) Government ☐ (1) Local Gov ☐ (2) Utilities ☐ (6) Private Sector ☐ (5) Academia ☐ (4) Community How is street address data sourced? (<i>tick all that apply</i>) ☒ Official government source ☐ Crowdsourced ☐ Private Sector Is street address data linked to a land parcel? ☒ Yes ☐ No Is street address data linked to a building? ☒ Yes ☐ No Is street address data collected according to a standard? ☒ Yes ☐ No If yes, what is the standard?: street addressing standard (local) _____ Is street address data updated regularly? ☐ Yes ☒ No			House Number	☒ Yes	☐ No	Building Name	☒ Yes	☐ No	Street Name	☒ Yes	☐ No	Locality Name (Parish, Town, City, Suburb etc.)	☐ Yes	☒ No	Postcode	☐ Yes	☒ No
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Postcode	☐ Yes	☒ No																

	If so, to what frequency? ☐ daily ☐ Weekly ☐ Monthly ☐ Annually
8	Do you have an Administrative Area Boundary dataset? Yes (nationwide) ☒ Yes (in some areas) ☐ No (text/paper only) ☐ <i>If No, does this apply to a specific boundary type only</i> _____ <i>Go to Question 9</i> If Yes, please answer the following: Which of the following features are collected? Government Administrative Units ☐ No ☒ Yes, Custodian: <u>GII</u> School Zones ☐ No ☒ Yes, Custodian: <u>MOE</u> Police Boundaries ☐ Yes, Custodian: _____ ☒ No Other ☐ Yes, Custodian: _____ ☐ No Are there duplicate or similar administrative boundary datasets? ☒ Yes ☐ No If yes, which ones? • Gov Adminboundary _____ Custodian: <u>CSA, GII</u> _____ Custodian _____ _____ Custodian _____ Are administrative boundaries a core government function? ☒ Yes ☐ No Is administrative boundary data accessible? ☒ Yes ☐ No If yes, how is the data accessed? <u>Through flesh and CD; open links</u> How often is the data accessed? : <u>Frequent</u> Who are the primary users? (<i>number 1-5, where 1 is the highest ranked category</i>) ☐ (3) Government ☐ (4) Local Gov ☐ (2) Utilities ☐ (5) Private Sector ☐ (1) Academia ☐ (6) Community How is administrative boundary data sourced? (<i>tick all that apply</i>) ☒ Official government sources ☐ Crowdsourced ☐ Private Sector IS there a standard for administrative are boundary data? ☐ Yes ☒ No If yes, what is the standard? _____

	Is administrative boundary data updated regularly? ☐ Yes ☒ No If so, to what frequency? ☐ daily ☐ Weekly ☐ Monthly ☐ Annually									
9	Do you have a Building Dataset? Yes (nationwide) ☐ Yes (in some areas) ☒ No (text/paper only) ☐ <i>If No, Go to Question 10</i> If Yes, please answer the following: Which of the following features are collected? <table style="width: 100%; border: none;"> <tr> <td style="width: 60%;">Building Footprint</td> <td style="width: 20%; text-align: center;">☒ Yes</td> <td style="width: 20%; text-align: center;">☐ No</td> </tr> <tr> <td>Building Points</td> <td style="text-align: center;">☒ Yes</td> <td style="text-align: center;">☐ No</td> </tr> <tr> <td>Building Purpose e.g. residential. commercial</td> <td style="text-align: center;">☒ Yes</td> <td style="text-align: center;">☐ No</td> </tr> </table> Who is the primary data custodian:- EThiotelecom Are there duplicate or similar building datasets? ☐ Yes ☒ No If so, who are the secondary data custodians? _____ _____ _____ Is building data a core government function? ☐ Yes ☒ No Is building data accessible? ☐ Yes ☒ No If yes, how is the data accessed? _____ How often is the data accessed? _____ Who are the primary users? (<i>number 1-5, where 1 is the highest ranked category</i>) ☐ (3) Government ☐ (2) Local Gov. ☐ (1) Utilities ☐ (4) Private Sector ☐ (6) Academia ☐ (5) Community How is building data sourced? (<i>tick all that apply</i>) ☒ Official government sources ☐ Crowdsourced ☐ Private Sector Are buildings linked to census information? ☐ Yes ☒ No Is building data collected according to a standard? ☐ Yes ☒ No If yes, what is the standard? _____ Is building data updated regularly? ☐ Yes ☒ No If so, to what frequency? ☐ daily ☐ Weekly ☐ Monthly ☐ Annually What is the accuracy of building data? e.g. +/- 2metres : 5 meters _____	Building Footprint	☒ Yes	☐ No	Building Points	☒ Yes	☐ No	Building Purpose e.g. residential. commercial	☒ Yes	☐ No
Building Footprint	☒ Yes	☐ No								
Building Points	☒ Yes	☐ No								
Building Purpose e.g. residential. commercial	☒ Yes	☐ No								

10	Do you have a Settlements Dataset? ☐ Yes (nationwide) ☒ Yes (in some areas) ☐ No (text/paper only) <i>If No Go to Question 11</i> If Yes, please answer the following: Which of the following features are collected? <table> <tr> <td>Settlement Boundary e.g. Built-up area</td> <td>☒ Yes</td> <td>☐ No</td> </tr> <tr> <td>Settlement Points</td> <td>☒ Yes</td> <td>☐ No</td> </tr> <tr> <td>Settlement Names</td> <td>☒ Yes</td> <td>☐ No</td> </tr> </table> Who is the primary data custodian <u>CSA</u> Are there duplicate or similar settlement datasets? ☐ Yes ☒ No If so, who are the secondary data custodians? _____ Is settlement data a core government function? ☒ Yes ☐ No Is settlement data accessible? ☒ Yes ☐ No If yes, how is the data accessed? <u>Counter</u> How often is the data accessed? <u>Regularly</u> Who are the primary users? (<i>number 1-5, where 1 is the highest ranked category</i>) ☐ (1)Government ☐ (2)Local Gov. ☐ (3)Utilities ☐ (4)Private Sector ☐ (6)Academia ☐ Community(5) How is settlement data sourced? (<i>tick all that apply</i>) ☒ from official government sources ☐ Crowdsourced ☐ Private Sector Are settlements linked to aggregated demographic data? ☒ Yes ☐ No Is settlement data collected according to a standard? ☐ Yes ☒ No If yes, what is the standard? _____ Is settlement data updated regularly? ☐ Yes ☒ No If so, to what frequency? ☐ daily ☐ Weekly ☐ Monthly ☐ Annually What is the accuracy of settlement data? e.g. <u>+/- 10metres</u>	Settlement Boundary e.g. Built-up area	☒ Yes	☐ No	Settlement Points	☒ Yes	☐ No	Settlement Names	☒ Yes	☐ No
Settlement Boundary e.g. Built-up area	☒ Yes	☐ No								
Settlement Points	☒ Yes	☐ No								
Settlement Names	☒ Yes	☐ No								

11 Do you have a **Land Parcel (cadastral boundary)** dataset?

Yes (nationwide) ☐ Yes (in some areas) ☒ No (text/paper only) ☐ *If No Go to Question 12*

If Yes, please answer the following:

Which of the following features are collected?

Parcel boundary ☒ Yes ☐ No

Surveyed boundary dimensions ☒ Yes ☐ No

Other _____

Who is the primary data custodian: **city administration: urban cadaster; RURAL land administration :rural cadaster** _____

Are there duplicate or similar land parcel datasets? ☐ Yes ☒ No

If so, who are the secondary data custodians? _____

Is land parcel data a core government function?

Local Government Function ☒ Yes ☐ No

National Government Function ☒ Yes ☐ No

Is land parcel data accessible? ☐ Yes ☒ No

If yes, how is the data accessed? _____

How often is the data accessed? _____

Who are the primary users? (*number 1-5, where 1 is the highest ranked category*)

☐ (1) Government ☐ (2) Local Gov. ☐ (3) Utilities ☐ (4) Private Sector ☐ (5) Academia

☐ (6) Community

How is land parcel data sourced? (*tick all that apply*)

☒ Official government sources ☐ Crowdsourced ☐ Private Sector surveyors

Are land parcels linked to property street addresses? ☒ Yes ☐ No

Are land parcels linked to the land titles (ownership) register data? ☒ Yes ☐ No

Is land parcel data collected according to a standard? ☒ Yes ☐ No

If yes, what is the standard? **Cadastral Standard, LADM**

Is land parcel data updated regularly? ☒ Yes ☐ No

If so, to what frequency? ☐ daily ☐ Weekly ☐ Monthly ☐ Annually

What is the accuracy of land parcel data? e.g. +/- 2metres: **20cm** _____

12	Do you have a Transport dataset? Yes (nationwide) ☐ Yes (in some areas) ☒ No (text/paper only) ☐ <i>If No, does this apply to a specific data type only _____</i> Is transport data a core government function? ☒ Yes ☐ No (<i>Go to Question 13</i>) If Yes, who is the <u>primary</u> data custodian <table style="width: 100%; border: none;"> <tr> <td style="width: 15%;">Roads</td> <td style="width: 15%;">☐ Yes, Custodian _____</td> <td style="width: 40%;"><u>Ethiopian_Road authority</u></td> <td style="width: 15%;">☐ No</td> </tr> <tr> <td>Rail</td> <td>☐ Yes, Custodian _____</td> <td><u>Ethiopian_Railway Corporation</u></td> <td>☐ No</td> </tr> <tr> <td>Cycle</td> <td>☐ Yes, Custodian _____</td> <td></td> <td>☒ No</td> </tr> <tr> <td>Bus</td> <td>☐ Yes, Custodian _____</td> <td></td> <td>☒ No</td> </tr> <tr> <td>Pedestrian</td> <td>☐ Yes, Custodian _____</td> <td></td> <td>☒ No</td> </tr> <tr> <td>Airways</td> <td>☒ Yes, Custodian _____</td> <td><u>Civil Aviation Authority</u></td> <td>☐ No</td> </tr> <tr> <td>Waterways</td> <td>☐ Yes, Custodian _____</td> <td></td> <td>☒ No</td> </tr> <tr> <td>Other</td> <td>☐ Yes, Custodian _____</td> <td></td> <td>☐ No</td> </tr> </table> Are there duplicate or similar transport datasets, and If so, who are the <u>secondary</u> data custodians? <table style="width: 100%; border: none;"> <tr> <td style="width: 15%;">Roads</td> <td style="width: 15%;">☒ Yes, Custodian: _____</td> <td style="width: 40%;"><u>city administrations</u></td> <td style="width: 15%;">☐ No</td> </tr> <tr> <td>Rail</td> <td>☐ Yes, Custodian _____</td> <td></td> <td>☒ No</td> </tr> <tr> <td>Cycle</td> <td>☐ Yes, Custodian _____</td> <td></td> <td>☒ No</td> </tr> <tr> <td>Bus</td> <td>☐ Yes, Custodian _____</td> <td></td> <td>☒ No</td> </tr> <tr> <td>Pedestrian</td> <td>☐ Yes, Custodian _____</td> <td></td> <td>☒ No</td> </tr> <tr> <td>Airways</td> <td>☐ Yes, Custodian _____</td> <td></td> <td>☒ No</td> </tr> <tr> <td>Waterways</td> <td>☐ Yes, Custodian _____</td> <td></td> <td>☒ No</td> </tr> <tr> <td>Other</td> <td>☐ Yes, Custodian _____</td> <td></td> <td>☒ No</td> </tr> </table> Does transport data have a classification system e.g. road hierarchies? ☒ Yes, if so which data types <u>road data</u> ☐ No Is transport data accessible? ☒ Publically ☐ Gov. Only ☐ Restricted ☐ No If yes, how is data accessed? ☒ Online ☒ Counter ☒ Email/ FTP Site If yes, how often accessed? ☐ Rarely ☒ Frequently	Roads	☐ Yes, Custodian _____	<u>Ethiopian_Road authority</u>	☐ No	Rail	☐ Yes, Custodian _____	<u>Ethiopian_Railway Corporation</u>	☐ No	Cycle	☐ Yes, Custodian _____		☒ No	Bus	☐ Yes, Custodian _____		☒ No	Pedestrian	☐ Yes, Custodian _____		☒ No	Airways	☒ Yes, Custodian _____	<u>Civil Aviation Authority</u>	☐ No	Waterways	☐ Yes, Custodian _____		☒ No	Other	☐ Yes, Custodian _____		☐ No	Roads	☒ Yes, Custodian: _____	<u>city administrations</u>	☐ No	Rail	☐ Yes, Custodian _____		☒ No	Cycle	☐ Yes, Custodian _____		☒ No	Bus	☐ Yes, Custodian _____		☒ No	Pedestrian	☐ Yes, Custodian _____		☒ No	Airways	☐ Yes, Custodian _____		☒ No	Waterways	☐ Yes, Custodian _____		☒ No	Other	☐ Yes, Custodian _____		☒ No
Roads	☐ Yes, Custodian _____	<u>Ethiopian_Road authority</u>	☐ No																																																														
Rail	☐ Yes, Custodian _____	<u>Ethiopian_Railway Corporation</u>	☐ No																																																														
Cycle	☐ Yes, Custodian _____		☒ No																																																														
Bus	☐ Yes, Custodian _____		☒ No																																																														
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Waterways	☐ Yes, Custodian _____		☒ No																																																														
Other	☐ Yes, Custodian _____		☐ No																																																														
Roads	☒ Yes, Custodian: _____	<u>city administrations</u>	☐ No																																																														
Rail	☐ Yes, Custodian _____		☒ No																																																														
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Airways	☐ Yes, Custodian _____		☒ No																																																														
Waterways	☐ Yes, Custodian _____		☒ No																																																														
Other	☐ Yes, Custodian _____		☒ No																																																														

Who are the primary users? (number 1-5, where 1 is the highest ranked category)

☐ (1) Government ☐ (2) Local Gov. ☐ (4) Utilities ☐ (3) Private Sector ☐ (5) Academia
☐ (6) Community

How is transport data sourced? (tick all that apply)

☒ Official government sources ☐ Crowdsourced ☒ Private Sector

Is transport data collected according to a standard? ☐ Yes ☒ No

If yes, what is the standard? _____

Is transport data updated regularly? ☐ Yes ☒ No

If so, to what frequency? Daily, weekly, monthly, annually

Roads ☐ Yes, Frequency _____ ☐ No

Rail ☐ Yes, Frequency _____ ☐ No

Cycle ☐ Yes, Frequency _____ ☐ No

Bus ☐ Yes, Frequency _____ ☐ No

Pedestrian ☐ Yes, Frequency _____ ☐ No

Airways ☐ Yes, Frequency _____ ☐ No

Waterways ☐ Yes, Frequency _____ ☐ No

Other ☐ Yes, Frequency _____ ☐ No

What is the accuracy of transport data? e.g. +/- 2metres

Roads City _____ Rural _____ Remote _____

Rail City _____ Rural _____ Remote _____

Cycle City _____ Rural _____ Remote _____

Bus City _____ Rural _____ Remote _____

Pedestrian City _____ Rural _____ Remote _____

Airways City _____ Rural _____ Remote _____

Waterways City _____ Rural _____ Remote _____

Other City _____ Rural _____ Remote _____

(Go to Question 10)

13	Do you have any Elevation Datasets? <table> <tr> <td>Yes (nationwide)</td> <td>Yes (in some areas)</td> <td>No (text/paper only)</td> </tr> <tr> <td>☒</td> <td>☐</td> <td>☐</td> </tr> </table> If no, Go to Question 14 If Yes, please answer the following: Which of the following are collected? <table> <tr> <td>Digital Elevation Model (DEM)</td> <td>☒ Yes</td> <td>☐ No</td> </tr> <tr> <td>Contours</td> <td>☒ Yes</td> <td>☐ No</td> </tr> <tr> <td>Spot Heights</td> <td>☒ Yes</td> <td>☐ No</td> </tr> </table> Who is the primary data custodian <u>Geospatial Information Institute</u> Are there duplicate or similar elevation datasets? ☒ Yes ☐ No If so, who are the secondary data custodians? <u>Ministry of water and Energy</u> <u>Ministry of Agriculture</u> <u>Water and Land resource Centre</u> Is elevation data a core government function? ☒ Yes ☐ No Is elevation data accessible? ☒ Yes ☐ No If yes, how is the data accessed? _____ How often is the data accessed? <u>Regularly</u> Who are the primary users? (number 1-5, where 1 is the highest ranked category) ☐ (1) Government ☐ (2) Local Gov. ☐ (3) Utilities ☐ (4) Private Sector ☐ (5) Academia ☐ (6) Community How is elevation data sourced? (tick all that apply) ☒ Official government sources ☐ Crowdsourced ☐ Private Sector Is elevation data collected according to a standard? ☐ Yes ☒ No If yes, what is the standard? _____ Is elevation data updated regularly? ☐ Yes ☒ No If so, to what frequency? ☐ daily ☐ Weekly ☐ Monthly ☐ Annually What is the accuracy of elevation data? e.g. +/- 2metres _____	Yes (nationwide)	Yes (in some areas)	No (text/paper only)	☒	☐	☐	Digital Elevation Model (DEM)	☒ Yes	☐ No	Contours	☒ Yes	☐ No	Spot Heights	☒ Yes	☐ No
Yes (nationwide)	Yes (in some areas)	No (text/paper only)														
☒	☐	☐														
Digital Elevation Model (DEM)	☒ Yes	☐ No														
Contours	☒ Yes	☐ No														
Spot Heights	☒ Yes	☐ No														

14	Do you have any Depth Datasets? <table border="0"> <tr> <td>Yes (nationwide)</td> <td>Yes (in some areas)</td> <td>No (text/paper only)</td> </tr> <tr> <td>☐</td> <td>☒</td> <td>☐</td> </tr> </table> If no, Go to Question 15 If Yes, please answer the following: Which of the following are collected? <table border="0"> <tr> <td>Bathymetry</td> <td>☒ Yes</td> <td>☐ No</td> </tr> <tr> <td>Soundings</td> <td>☒ Yes</td> <td>☐ No</td> </tr> </table> Who is the primary data custodian: <u>MOWIE (ministry of water and Energy)</u> Are there duplicate or similar depth datasets? ☒ Yes ☐ No If so, who are the secondary data custodians? <u>Addis Ababa University</u> Is depth data a core government function? ☒ Yes ☐ No Is depth data accessible? ☒ Yes ☐ No If yes, how is the data accessed? <u>COUNTER</u> How often is the data accessed? <u>RARLEY</u> Who are the primary users? (number 1-5, where 1 is the highest ranked category) ☐ (1) Government ☐ (4) Local Gov. ☐ (3) Utilities ☐ (5) Private Sector ☐ (2) Academia ☐ (6) Community How is elevation data sourced? (tick all that apply) ☒ Official government sources ☐ Crowdsourced ☐ Private Sector How is bathymetry data sourced? (tick all that apply) ☒ Official government sources ☐ Crowdsourced ☐ Private Sector Is bathymetry data collected according to a standard? ☐ Yes ☒ No If yes, what is the standard? _____	Yes (nationwide)	Yes (in some areas)	No (text/paper only)	☐	☒	☐	Bathymetry	☒ Yes	☐ No	Soundings	☒ Yes	☐ No
Yes (nationwide)	Yes (in some areas)	No (text/paper only)											
☐	☒	☐											
Bathymetry	☒ Yes	☐ No											
Soundings	☒ Yes	☐ No											

15

Do you have any **Population Datasets**?

	Yes (nationwide)	Yes (in some areas)	No (text/paper only)
Census	☒	☐	☐
Other	☐	☐	☐

If no, Go to Question 16

If Yes, please answer the following:

Which of the following are collected?

Demographics	☒ Yes	☐ No
Household Information	☒ Yes	☐ No
Workforce Statistics	☒ Yes	☐ No
Diversity (Gender, disability, ethnicity)	☒ Yes	☐ No

Who is the primary data custodian: CSA (Central Statistics Authority)Are there duplicate or similar population datasets? ☐ Yes ☒ No

If so, who are the secondary data custodians? _____

Is population data a core government function? ☒ Yes ☐ NoIs population data accessible? ☒ Yes ☐ NoIf yes, how is the data accessed? Online, CD/FLASHHow often is the data accessed? Regularly

Who are the primary users? (number 1-5, where 1 is the highest ranked category)

☐ (1) Government
 ☐ (2) Local Gov.
 ☐ (3) Utilities
 ☐ (5) Private Sector
 ☐ (4) Academia
 ☐ (6) Community

How is population data sourced? (tick all that apply)

☒ Official government sources
 ☐ Crowdsourced
 ☐ Private Sector
Is population data collected according to a standard? ☐ Yes ☒ No

If yes, what is the standard? _____

Is population data updated regularly? ☐ Yes ☒ NoIf so, to what frequency? ☐ daily ☐ Weekly ☐ Monthly ☐ Annually

16	Do you have any Land Cover and Land Use Datasets? <table> <tr> <td>Yes (nationwide)</td> <td>Yes (in some areas)</td> <td>No (text/paper only)</td> </tr> <tr> <td>☒</td> <td>☐</td> <td>☐</td> </tr> </table> If no, Go to Question 17 If Yes, please answer the following: Which of the following are collected? <table> <tr> <td>Vegetation Cover</td> <td>☒ Yes</td> <td>☐ No</td> </tr> <tr> <td>Land Use</td> <td>☒ Yes</td> <td>☐ No</td> </tr> </table> Who is the primary data custodian: <u>(GII) Geospatial Information Institute</u> Are there duplicate or similar land cover and land use datasets? ☒ Yes ☐ No If so, who are the secondary data custodians? <u>MINISTRY OF AGRICULTURE</u> <u>Forest and Climate Change Commission</u> Is land cover and land use data a core government function? ☒ Yes ☐ No Is land cover and land use data accessible? ☒ Yes ☐ No If yes, how is the data accessed? <u>Online, Counter</u> How often is the data accessed? <u>Regular</u> Who are the primary users? (<i>number 1-5, where 1 is the highest ranked category</i>) ☐ (1) Government ☐ (2) Local Gov. ☐ (3) Utilities ☐ (5) Private Sector ☐ (4) Academia ☐ (6) Community How is land cover and land use data sourced? (<i>tick all that apply</i>) ☒ Official government sources ☐ Crowdsourced ☐ Private Sector Is land cover and land use data collected according to a standard? ☐ Yes ☒ No If yes, what is the standard? _____ Is land cover and land use data updated regularly? ☐ Yes ☒ No If so, to what frequency? ☐ daily ☐ Weekly ☐ Monthly ☐ Annually	Yes (nationwide)	Yes (in some areas)	No (text/paper only)	☒	☐	☐	Vegetation Cover	☒ Yes	☐ No	Land Use	☒ Yes	☐ No
Yes (nationwide)	Yes (in some areas)	No (text/paper only)											
☒	☐	☐											
Vegetation Cover	☒ Yes	☐ No											
Land Use	☒ Yes	☐ No											

17

Do you have any **Geology and Soils Datasets**?

Yes (nationwide)

☒

Yes (in some areas)

☐

No (text/paper only)

☐

If no, Go to Question 18

If Yes, please answer the following:

Which of the following are collected?

Geology

☒

Yes

☐

No

Soils

☒

Yes

☐

No

Minerals

☒

Yes

☐

No

Who is the primary data custodian: Geological Survey of Ethiopia, ATA (Ministry Of Agriculture)

Are there duplicate or similar geology and soils datasets?

☐ Yes☐ No

If so, who are the secondary data custodians?

BASIN authoritiesRegional Bureaus

Is geology and soils data a core government function?

☒ Yes☐ No

Is geology and soils data accessible?

☒ Yes☐ No

If yes, how is the data accessed?

CD/Flash; Online

How often is the data accessed?

Regular

Who are the primary users? (number 1-5, where 1 is the highest ranked category)

☐ (1) Government☐ (2) Local Gov.☐ (3) Utilities☐ (5) Private Sector☐ (4) Academia☐ (6) Community

How is geology and soils data sourced? (tick all that apply)

☒

Official government sources

☐

Crowdsourced

☐

Private Sector

Is geology and soils data collected according to a standard?

☐ Yes☒

No

If yes, what is the standard?

Is geology and soils data updated regularly?

☐ Yes☒ No

If so, to what frequency?

☐ daily☐ Weekly☐ Monthly☐ Annually

18

Do you have any **Utilities Datasets**?

Yes (nationwide)

☐

Yes (in some areas)

☒

No (text/paper only)

☐

If Yes, please answer the following:

If no, Go to Question 19

Which of the following are collected?

Electricity ☒ Yes ☐ NoDrainage ☒ Yes ☐ NoSewage ☒ Yes ☐ NoTelecommunications ☒ Yes ☐ NoWho is the primary data custodian _____Electricity ☐ Yes, Custodian _____ EELPA ☐ NoDrainage ☐ Yes, Custodian _____ EELPA ☐ NoSewage ☐ Yes, Custodian _____ WSSA ☐ NoTelecommunications ☐ Yes, Custodian _____ ETHio_telecom ☐ NoAre there duplicate or similar utilities datasets? ☐ Yes ☒ NoWho is the secondary data custodian _____Electricity ☐ Yes, Custodian _____ ☐ NoDrainage ☐ Yes, Custodian _____ ☐ NoSewage ☐ Yes, Custodian _____ ☐ NoTelecommunications ☐ Yes, Custodian _____ ☐ NoIs utilities data a core government function? ☒ Yes ☐ NoIs utilities data accessible? ☒ Yes ☐ NoIf yes, how is the data accessed? _____ Counter

How often is the data accessed? _____

Who are the primary users? (number 1-5, where 1 is the highest ranked category)

☒ (1) Government ☐ (3) Local Gov. ☐ (1) Utilities ☐ (4) Private Sector ☐ (5) Academia
☐ (6) Community

How is utilities data sourced? (tick all that apply)

☒ Official government sources ☐ Crowdsourced ☐ Private SectorIs utilities data collected according to a standard? ☐ Yes ☒ No

If yes, what is the standard? _____

	Is utilities data updated regularly? ☐ Yes ☒ No If so, to what frequency? ☐ daily ☐ Weekly ☐ Monthly ☐ Annually
19	Do you have any Water Datasets? Yes (nationwide) ☒ Yes (in some areas) ☐ No (text/paper only) ☐ If Yes, please answer the following: If no, Go to Question 20 Which of the following are collected? Lakes/Streams ☒ Yes ☐ No Oceans/Seas ☐ Yes ☐ No Bays/Estuaries/Inlets ☐ Yes ☐ No Territorial Sea Boundaries ☐ Yes ☐ No Who is the <u>primary</u> data custodian _____ Lakes/Streams ☐ Yes, Custodian: <u>MOWIE (Ministry of Water And energy)</u> ☐ No Oceans/Seas ☐ Yes, Custodian _____ ☐ No Bays/Estuaries/Inlets ☐ Yes, Custodian _____ ☐ No Territorial Sea Bdy's ☐ Yes, Custodian _____ ☐ No Are there duplicate or similar utilities datasets? ☒ Yes ☐ No Who is the <u>secondary</u> data custodian _____ Lakes/Streams ☐ Yes, Custodian: <u>WLRC, Basin Authorities ;Forest and climate change commission (FCC)</u> ☐ No Oceans/Seas ☐ Yes, Custodian _____ ☐ No Bays/Estuaries/Inlets ☐ Yes, Custodian _____ ☐ No Territorial Sea Bdy's ☐ Yes, Custodian _____ ☐ No Is water data a core government function? ☒ Yes ☐ No Is water data accessible? ☒ Yes ☐ No If yes, how is the data accessed? <u>Online, Counter</u> _____ How often is the data accessed? <u>Regularly</u> Who are the primary users? (number 1-5, where 1 is the highest ranked category) ☒ (1) Government ☐ (2) Local Gov ☐ (3) Utilities ☐ (5) Private Sector ☐ (4) Academia ☐ (6) Community How is water data sourced? (tick all that apply)

	☒ Official government sources ☐ Private Sector	
	Is water data collected according to a standard? ☐ Yes ☒ No	
	If yes, what is the standard? _____	
	Is water imagery data captured regularly? Yes ☐ Monthly ☐ Annually ☒ NO	
20	Do you have any Imagery Datasets?	
	Yes (nationwide) ☒	Yes (in some areas) ☐
	No (text/paper only) ☐	
	If Yes, please answer the following:	
	If no, Go to Question 21	
	Which of the following are collected?	
	Aerial Photography ☒ Yes SOME AREA ☐ No	
	LiDAR Imagery ☒ Yes SOME AREA ☐ No	
	Satellite Imagery ☒ Yes ☐ No	
	Drone Imagery ☐ Yes ☒ No	
	Who is the <u>primary</u> data custodian <u>GII</u> ,	
	Aerial Photography ☒ Yes, Custodian <u>GII</u> ☐ No	
	LiDAR Imagery ☒ Yes, Custodian <u>GII</u> ☐ No	
	Satellite Imagery ☒ Yes, Custodian <u>GII</u> ☐ No	
	Drone Imagery ☐ Yes, Custodian ☒ No	
	Are there duplicate or similar imagery datasets? ☒ Yes ☐ No	
	Who is the <u>secondary</u> data custodian _____	
	Aerial Photography ☒ Yes, Custodian <u>Regions ,city admin</u> ☐ No	
	LiDAR Imagery ☒ Yes, Custodian <u>ERC, MOM</u> ☐ No	
	Satellite Imagery ☒ Yes, Custodian <u>MOA</u> ☐ No	
	Drone Imagery ☐ Yes, Custodian _____ ☒ No	
	Is Imagery data a core government function? ☒ Yes ☐ No	
	Is Imagery data accessible? ☒ Yes ☐ No	
	If yes, how is the data accessed? <u>counter</u>	
	How often is the data accessed? <u>On demand</u>	
	Who are the primary users? (number 1-5, where 1 is the highest ranked category)	

	☐ (1) Government ☐ (2) Local Gov ☐ (3) Utilities ☐ (5) Private Sector ☐ (4) Academia ☐ (6) Community
	How is imagery data sourced? <i>(tick all that apply)</i>
	☒ Official government sources ☐ Private Sector
	Is imagery data collected according to a standard? ☐ Yes ☒ No
	If yes, what is the standard?
Is aerial imagery data captured regularly? Yes	☐ Monthly ☐ Annually ☒ NO

Strategic Pathway 5: Standards

The following questions are designed to understand the data and ICT standards that are currently in place and the level of compliance for integrated geospatial information management.

1	Is there a policy framework in place that promotes the use of and compliance with geospatial standards across the government sector? ☒ Yes ☐ No
2	Are there national standards in place for geospatial data, metadata and services? ☐ Yes ☒ No
3	Are standards and implementation experiences being documented and disseminated? ☐ Yes ☒ No <i>(Go to Question 5)</i>
4	Is there a mandated organisation responsible for the localisation, adoption, publication and compliance monitoring of these standards? ☒ Yes ☐ No
5	Does a national law or regulation exist that mandates the use of geospatial standards? ☒ Yes ☐ No
6	Is the use of geospatial standards mandated in procurement of geospatial software and services? ☐ Yes ☒ No
7	Is there national representation in the international standards organisations? ☒ Yes ☐ No
8	What mechanisms exist for engagement across a range of domains that encourage adoption and use of geospatial standards? ☒ Policy ☐ Law/regulation ☒ Mandates ☐ Guidelines and work procedures ☐ Other: _____
9	Are staff typically aware of the standards that their work needs to comply with? ☐ Yes ☒ No Other: _____

Strategic Pathway 6: Innovation

The following questions are designed to understand the technology and processes to share and disseminate integrated geospatial information management.

1	Is there an ICT infrastructure in place that can be used for sharing geospatial information? ☒ Yes ☐ No <i>(Go to Question 3)</i> If yes, which scenario/s exist: ☐ There is a single portal for government data ☒ There is more than one portal for government data ☐ Most government institutions have their own portal ☐ Other reason _____ If there is more than one portal, please specify the known portals: 1. <u>WLRC (Water and Land Resource Centre) Portal</u> 2. <u>ENSDI (Ethiopian National Spatial Data Infrastructure)</u> 3. <u>Geological Survey of Ethiopia Portal</u>

2	Are the portal, data and services multilingual? Please tick which apply. National language only ☐ Portal ☐ Data ☐ Services Native (Ethnic) dialects ☐ Portal ☐ Data ☐ Services English language ☒ Portal ☒ Data ☒ Services Comments _____
3	Does the government have an organisation responsible for coordinating innovation? ☒ Yes ☐ No (Go to Question 4) If yes, which scenario/s exist? Please tick those that apply. ☒ There a methodology to encourage and exploit innovation. ☒ Geospatial technologies included in government's innovation efforts. ☐ There are incentives for innovation that uses geospatial information. ☒ There are small start-up incubators for entrepreneurs. ☒ There are innovation hubs for research and development. ☐ Other _____
4	Is the <u>academic sector</u> involved in research programs related to geospatial information? ☒ Yes ☐ No (Go to Question 5) If yes, list the type of research projects: 1. <u>Applied Research</u>
5	Is the <u>private sector</u> involved in research programs related to geospatial information? ☐ Yes ☒ No (Go to Question 6) If yes, list the type of research projects: _____ _____ _____ _____ _____
6	Is the private sector building end-user services or applications based on government geospatial information?

	☐ Yes ☒ No (Go to Question 7)
	If yes, list the type of applications developed::

7	Is crowd-sourced data being used in the national geospatial infrastructure? ☐ Yes ☒ No (Go to Question 8)
	If yes, which datasets does crowdsourced data contribute to:

8	What type of storage is used to store data? Options include: • Cloud Computing • Network Attached Storage (NAS) e.g. Mainframe Computing • Portable Storage e.g. CDROM, Portable Hard drive • Personal Computer Hard Disk • Other Tick all that apply for each organisation. Organisation Name
	GII_____ ☐ Cloud ☒ NAS ☒ Portable HD ☒ Computer ☐ Other
	WLRC _____ ☐ Cloud ☒ NAS ☒ Portable HD ☒ Computer ☐ Other
	Geology _____ ☐ Cloud ☒ NAS ☒ Portable HD ☒ Computer ☐ Other
	CSA _____ ☐ Cloud ☒ NAS ☒ Portable HD ☒ Computer ☐ Other

	_____ ☐ Cloud ☐ NAS ☐ Portable HD ☐ Computer ☐ Other _____ ☐ Cloud ☐ NAS ☐ Portable HD ☐ Computer ☐ Other _____ ☐ Cloud ☐ NAS ☐ Portable HD ☐ Computer ☐ Other _____ ☐ Cloud ☐ NAS ☐ Portable HD ☐ Computer ☐ Other _____ ☐ Cloud ☐ NAS ☐ Portable HD ☐ Computer ☐ Other _____ ☐ Cloud ☐ NAS ☐ Portable HD ☐ Computer ☐ Other
8	Is there a national geospatial research agenda (or similar)? ☒ Yes ☐ No If yes, answer the statements below (Tick all that apply) The agenda meets the requirements of a changing nation. ☐ Yes ☒ No The agenda includes international research cooperation. ☐ Yes ☒ No The agenda is application focused to meet the needs of end users ☒ Yes ☐ No The agenda is focused data production and integration ☐ Yes ☒ No

Strategic Pathway 7: Partnerships

The following questions are designed to understand the extent to which partnerships are currently leveraged to strengthen integrated geospatial information management.

1	Are staff typically aware of the standards that their work needs to comply with? ☐ Yes ☒ No Other: _____																																																								
2	To what extent have strategic partnerships evolved at the national level to support geospatial information management? <table border="0"> <tr> <td>Development of technology</td> <td>☐ Minimal</td> <td>☐ Moderate</td> <td>☐ High</td> </tr> <tr> <td>Data Acquisition</td> <td>☐ Minimal</td> <td>☐ Moderate</td> <td>☐ High</td> </tr> <tr> <td>Data Maintenance</td> <td>☐ Minimal</td> <td>☐ Moderate</td> <td>☐ High</td> </tr> <tr> <td>Data Sharing</td> <td>☐ Minimal</td> <td>☐ Moderate</td> <td>☐ High</td> </tr> <tr> <td>Deliver training</td> <td>☐ Minimal</td> <td>☐ Moderate</td> <td>☐ High</td> </tr> <tr> <td>Shared Decision Making (Committees)</td> <td>☐ Minimal</td> <td>☐ Moderate</td> <td>☐ High</td> </tr> <tr> <td>Organisational Restructuring</td> <td>☐ Minimal</td> <td>☐ Moderate</td> <td>☐ High</td> </tr> <tr> <td>Development of Applications</td> <td>☐ Minimal</td> <td>☐ Moderate</td> <td>☐ High</td> </tr> <tr> <td>Broad User Community Participation</td> <td>☐ Minimal</td> <td>☐ Moderate</td> <td>☐ High</td> </tr> <tr> <td>Research and Development</td> <td>☐ Minimal</td> <td>☐ Moderate</td> <td>☐ High</td> </tr> <tr> <td>Public Private partnerships</td> <td>☐ Minimal</td> <td>☐ Moderate</td> <td>☐ High</td> </tr> <tr> <td>Funding Alliances</td> <td>☐ Minimal</td> <td>☐ Moderate</td> <td>☐ High</td> </tr> <tr> <td>Other _____</td> <td>☐ Minimal</td> <td>☐ Moderate</td> <td>☐ High</td> </tr> <tr> <td>Other _____</td> <td>☐ Minimal</td> <td>☐ Moderate</td> <td>☐ High</td> </tr> </table> NB: There are no strategic partnerships, but there are some operational/project based partnerships	Development of technology	☐ Minimal	☐ Moderate	☐ High	Data Acquisition	☐ Minimal	☐ Moderate	☐ High	Data Maintenance	☐ Minimal	☐ Moderate	☐ High	Data Sharing	☐ Minimal	☐ Moderate	☐ High	Deliver training	☐ Minimal	☐ Moderate	☐ High	Shared Decision Making (Committees)	☐ Minimal	☐ Moderate	☐ High	Organisational Restructuring	☐ Minimal	☐ Moderate	☐ High	Development of Applications	☐ Minimal	☐ Moderate	☐ High	Broad User Community Participation	☐ Minimal	☐ Moderate	☐ High	Research and Development	☐ Minimal	☐ Moderate	☐ High	Public Private partnerships	☐ Minimal	☐ Moderate	☐ High	Funding Alliances	☐ Minimal	☐ Moderate	☐ High	Other _____	☐ Minimal	☐ Moderate	☐ High	Other _____	☐ Minimal	☐ Moderate	☐ High
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3	What type of funding alliances exist? ☒ Large grant/donation ☒ Recipient/donor relationship. ☐ Cost-sharing between institutions e.g. facilities, staff or equipment. ☐ Grant-match ☐ In-kind services, cash, maintenance, supplies, or volunteers ☐ Other _____																																																								

Strategic Pathway 8: Education and Capacity

The following questions are designed to understand the extent to which education and capacity development takes place for strengthening integrated geospatial information management.

1	Is there insight, such as an inventory, into the status and availability of geospatial skills nationally? ☒ Yes ☐ No (Got to Question 2) If yes, please describe how this information is gathered and recorded. <u>Base line study and assessment research(documented)</u>
2	Is there a culture of learning and innovation across government and the private sector? ☐ Yes ☒ No (Got to Question 3)
3	Is there collaboration between different stakeholders (government, private sector, academic sector) to set the research and educational priorities? ☐ Yes ☒ No (Got to Question 4) If yes, please explain how this collaboration occurs. _____ _____ _____ _____ _____ _____
4	Is there an active approach to knowledge and best practice sharing across government and the private sector?

	☐ Yes _____ ☒ No (Got to Question 5)

5	What geospatial-related educational programs exist at primary, secondary and tertiary levels?			
	• <u>Geography (at primary and secondary level)</u> _____ • <u>Land management, surveying (at TVET level)</u> • <u>GIS and remote sensing, geodesy, geomatics engineering, surveying, land administration, Geoinformatics, geography and environmental studies (BSC, MSC, PhD)</u>			
6	Are geospatial data analysis and interpretation skills part of the geography curriculum? ☒ Yes ☐ No			
7	Are geospatial-related capacity building programs available and to what extent are they used? ☒ Yes ☐ No (Got to Question 8)			
	If yes, what sort of programs?			
	☐ Professional Workplace Training	☐ Minimal	☒ Moderate	☐ High
	☐ Intensive Training Courses	☒ Minimal	☐ Moderate	☐ High
	☐ Facilitated Workshops	☒ Minimal	☐ Moderate	☐ High
	☐ Scholarship Programs	☒ Minimal	☐ Moderate	☐ High
	☐ Internships	☒ Minimal	☐ Moderate	☐ High
	☐ Study Tours	☐ Minimal	☒ Moderate	☐ High
	☐ International Fellowship Programs	☐ Minimal	☒ Moderate	☐ High
	☐ Innovation Hubs	☒ Minimal	☐ Moderate	☐ High
	☐ Small Startup Incubators	☒ Minimal	☐ Moderate	☐ High
	☐ E-Learning	☒ Minimal	☐ Moderate	☐ High
	☐ Partnerships and Networking	☒ Minimal	☐ Moderate	☐ High
	☐ Professional Certification Programs	☒ Minimal	☐ Moderate	☐ High
	☐ Technical Expertise/Advice	☒ Minimal	☐ Moderate	☐ High
	☐ Coaching and Mentoring Programs	☒ Minimal	☐ Moderate	☐ High
	☐ Leadership Development	☒ Minimal	☐ Moderate	☐ High
	☐ Awareness Campaigns	☒ Minimal	☐ Moderate	☐ High
	☐ Advocacy	☒ Minimal	☐ Moderate	☐ High
	☐ Peer Support	☐ Minimal	☐ Moderate	☐ High
	☐ Other _____	☐ Minimal	☐ Moderate	☐ High
	☐ Other _____	☐ Minimal	☐ Moderate	☐ High

Strategic Pathway 9: Communication and Engagement

The following questions are designed to understand the extent to which stakeholder engagement is leveraged to strengthen integrated geospatial information management.

1	Have the stakeholders, partners and users of geospatial information been identified? ☒ Yes ☐ No (<i>Go to Question 2</i>) If so, have stakeholders been categorised, e.g. groups that share common interests in creating and using geospatial information? ☐ Yes ☒ No
2	Is there a stakeholder communication and engagement strategy and plan? ☐ Yes ☒ No
3	Is there a process in place for engaging with stakeholders on matters relating to geospatial information management; one that allows stakeholders to contribute feedback on their needs? ☐ Yes ☒ No (<i>Go to Question 4</i>) If yes, what type of forum? <i>Please Select any that apply.</i> ☐ Regular Forums and Conferences ☐ Cabinet Submissions ☐ Briefing Sessions ☐ Regular/ad hoc Meetings ☐ External Committee or Working Group ☐ Professional Association representing industry ☐ Professional Association representing individual practitioners ☐ Online feedback system/portal ☐ Print Media ☐ Satisfaction Surveys ☐ Questionnaires ☐ Other _____

4

Are there support systems in place for users of government geospatial information?

☐ Yes

☒ No

If yes, what type of support system? *Please Select any that apply.*

☐ Help desk

☐ Guidance notes/ technical manuals/ leaflets

☐ Telephone support

☐ Online information pages e.g. Frequently Asked Questions (FAQs)

☐ An opportunity/function for user feedback

☐ Other _____

Appendix 6: Environmental Scanning – Ethiopia

PURPOSE:

Environmental Scanning is an assessment of the internal and external factors having an impact on geospatial information management. Understanding the broader environment may lead to the identification of new opportunities, and strategies or actions to deal with any issues that are a threat to the success of the Strategic Framework.

Environmental Scanning is achieved using the PEST and SWOT Analysis Tools, and is best undertaken with a group of stakeholders, and ideally in a workshop setting. Having a facilitator who is not a participant helps to manage the success of the workshop discussion.

Workshop discussions were convened on 26, 27 and 29 July 2019.

Chairperson: Belachew Tsehay

Minutes: Slehak Melak

Stakeholders: Berihu Alemayehu; Dereje Mekonnen; Habtamu Sewunet; Eyasu Lema; Tsegaye Ayele; and Firesew Feyso.

PEST ANALYSIS:

The PEST Analysis considers the external environment and focusses on the **P**olitical, **E**conomic, **S**ocial and **T**echnology issues that may have a positive or negative impact on the implementation of integrated geospatial information management.

An example of issues that may be raised during a PEST Analysis are presented below.

POLITICAL	ECONOMIC	SOCIAL	TECHNOLOGICAL
• Safer country • Policy and legislation • E-Government • Regional needs • Sufficient government support and funding • Copyright and Intellectual Property • Value and importance to the country	• Investment • Opportunities for revenue growth • Savings • Modernisation and maintenance • Professional skills • Plant, equipment and personnel availability • Public-Private Partnerships	• Institutional culture • Community needs • Intergenerational issues • Geographic and geospatial education capacity • Computer literacy • Community safety	• Data quality • Legislation • Technology level • Power (utilities) availability • Broadband capacity • Standards, metadata etc. • Innovation

SWOT ANALYSIS:

The SWOT Analysis considers internal factors; namely the characteristics of government that are an advantage or disadvantage to geospatial information management, those aspects that can be exploited to advantage through implementation of the Strategic Framework, and those realities that are a threat to its implementation. While threats are often considered to be out of direct control, they may still have an influence on outcomes and be able to make a valuable contribution. For example, while legislators are responsible for drafting Open Data Policies, geospatial professionals will have specialist expertise that help shape the policies to bring out the opportunities.

Strengths: characteristics of government that are an advantage to the Strategic Framework.

Weaknesses: characteristics that place the Strategic Framework at a disadvantage.

Opportunities: elements that the Strategic Framework could exploit to its advantage.

Threats: elements in the environment that could raise issues for the Strategic Framework during and after its implementation.

An example of issues that may be raised during a SWOT Analysis are presented below.

STRENGTHS	WEAKNESSES	OPPORTUNITIES	THREATS
• Leadership • Skills • Technology • Research and development • Community demand	• Missing, outdated, or sub-standard data themes • Policy • Cross agency collaboration • ROI and pricing models	• Expansion of data use • New applications • Community crowdsourcing • Government branding • Community trust	• Free data policy impacts on ROI • Change in policies • Consumer behaviour • Obsolete technology • Insufficient resources

PEST ANALYSIS - POLITICAL ISSUES:

What national strategies will benefit from having access to geospatial information; and what aspects of the political environment will create a barrier to the implementation of integrated geospatial information?

Benefiting Strategies	Barriers to Implementation
1. Peace and security strategy 2. Sustainable land management 3. E-Government 4. Food security strategy	1. Political Unstable 2. Not sufficient government funding 3. Conflict of mandate

5. Disaster preparedness and recovery strategy 6. Energy development strategy 7. Urban development and management strategy 8. Natural Resource conservation and development strategy 9. Infrastructure development strategy 10. Investment strategy 11. Industrialisation strategy 12. National truism strategy 13. National sustainable Public health strategy 14. Education expansion and quality strategy 15. ReDD+ reducing emissions, forest degradation and deforestation 16. Water and energy development strategy	4. Lack of commitment 5. Lack of Policy implementation 6. Law enforcement problems 7. Security crises 8. Poor organisational culture.

PEST ANALYSIS - ECONOMIC ISSUES:

How will government, industry and the community benefit economically from having access to geospatial information; and what aspects will create a barrier to the development of the Strategic Framework?

Economic Benefits	Barriers to Implementation
- Investment opportunities via resource identification - Contribute for Improve living standard - Improve productivity - Reduce cost and save time through improved decision making and planning - Crate employment opportunities - Enhance tax revenue - Assure tenure Security through cadastre /land certification/	- Shortage of Budget and foreign currency - Lack of financial model - Poor procurement procedure - Poor understanding of the economic benefit of using geospatial information - Unknown return on investment of geospatial initiatives - Poor insight on the potential usage of collected spatial data (Lack of reusability) - Data duplication and redundancy in data acquisition and production

	• Long business process • Low per capita income

PEST ANALYSIS - SOCIAL ISSUES:

How will the community benefit socially from having access to geospatial information; and what social aspects will create a barrier to the development and use of integrated geospatial information by the broader community?

Social Benefits	Barriers to Implementation
• Contribute for Improve living standard • Easy mobility • Understanding of the local environment • Easy access to facilities • Facilitate community development activity • Create employment opportunity • Informed re-settlement • Monitoring of cultural ,religious, natural heritage • Monitor demographic statues in size and distribution • Ensure public safety	• Poor spatial information usage culture • Poor data sharing culture • Lack of awareness • Dominant agrarian culture • Poor attitudes toward work, leisure, career and retirement • Low education level and poor quality of education

PEST ANALYSIS - TECHNOLOGY ISSUES:

What technology and data issues will have an influence on implementing the Strategic Framework and the provision of access to geospatial information?

We identified the following issues below:

- Not having space asset like own satellites
- Weak telecommunication infrastructure
- Dependency on proprietary software
- Absence of standards (metadata, interoperability, content...)
- Technology dynamism
- Absence of legal framework regards data and technology
- Absence of data on some thematic areas
- Poor internet connectivity
- Shortage of skilled man power
- Lack of technology incentives
- Prevailing outdated technologies
- Lack of research on the geospatial technologies
- Availability of open source data and technologies
- Positive trend in the use of geospatial data and technologies in space and time.
- Expansion of geospatial technology suppliers.

SWOT ANALYSIS - STRENGTHS:

We focused on what we do well for successful implementation of integrated geospatial information and the provision of quality geospatial information, then we point out the following issues:

- Internal resources (aerial surveying)
- Basic infrastructure level
- Access to newest technology
- Community demand
- Availability of policy document for geospatial technology and information.

SWOT ANALYSIS - WEAKNESSES:

We focused on things that will help us to achieve integrated geospatial information management. These are:

- Lack of Leadership
- Low priority for budget and investment
- Gap in technology skills capacity

- Poor data quality
- Data sets required have not been collected i.e. address data
- Standards and metadata
- Research and development
- Technology incentives
- Legislation regarding data and technology
- Technology level in your industry
- Communication infrastructure
- Internet and Broadband capacity
- Access to newest technology
- Internet infrastructure and market/community penetration
- Political will
- Poor institutional arrangement
- Limited stakeholders collaboration

SWOT ANALYSIS - OPPORTUNITIES:

We focused on what the government is able to offer to the industry for the successful implementation of integrated geospatial information management and easy access to geospatial information. These are:

1. New applications in the following areas

- Environment
- Urban (Utility, planning, green area....)
- Agriculture
- Health
- Resources
- Disaster Management
- Emergency Services
- Biosecurity
- Defence
- Land and Property Administration
- Social /Community Applications
- Other

2. Benefits to government

- Community crowdsourcing
- Data sharing
- Positive government branding and improved image

- Community trust
- Economic benefits
- Employment
- Informed decision

3. Benefit to the private sector

- Technology availability
- Product and service delivery
- Innovation

4. Benefit to the community

- Ease of life / living standard
- Secure access to information right
- Cost reduction

SWOT ANALYSIS - THREATS:

We focused on things beyond our control in implementation of integrated geospatial information management. These are:

- Free data policy impacts on revenues
- Change in government leadership and policy
- Public reaction
- Shifts in consumer behaviour, the economy, or government regulations that could reduce your sales
- Data quality not up to consumer expectations
- Technology becomes obsolete (dynamic)
- Research trends
- Organisational culture
- Economic trends (unpredictability)
- Insufficient resources