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Sustainable Development Goals Connectivity Dilemma

Land and Geospatial Information for Urban and Rural Resilience

EDITED BY

Abbas Rajabifard

UN-GGIM
ACADEMIC NETWORK

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Contents

Forewords

Foreword by Mr. Stefan Schweinfest:

It gives me great pleasure to be able to provide this Foreword as my contribution to this book, which is in itself an immensely important initiative from our UN-GGIM Academic Network, one of our strategic arms of UN-GGIM. This book represents a very tangible and direct means towards bringing together knowledge and experiences from around the globe to build upon and facilitate our strategy, plans and approaches for geospatially enabling the implementation and monitoring of the Sustainable Development Goals (SDGs), and for proposing a potential roadmap to achieving a better world for all and leaving no one behind.

As you will know, the 2030 Agenda for Sustainable Development is intentionally ambitious, providing a transformative and integrated approach to sustainable development, and is anchored by a set of 17 integrated and indivisible SDGs, 169 targets, and a global indicator framework, in order to measure and monitor progress. The 2030 Agenda is a new and universal development agenda for all countries and stakeholders to use as a blueprint for action, and calls for concerted efforts towards building an inclusive, sustainable and resilient future for people, planet and prosperity.

The SDGs are unique in that they universally apply to all countries as we collectively manage and transform the social, economic and environmental dimensions of people and the planet through to at least 2030. The SDGs are a compass for aligning countries' national plans and aspirations with their global commitments. All stakeholders; governments, industry, academia, the private sector and civil society are expected to contribute to the realization of the 2030 Agenda.

In this context, our efforts within the intergovernmental processes of UN-GGIM include raising awareness and paving the path forward for a better future for all. We need strategies that build economic growth and address a range of societal needs, while tackling climate change and environmental protection. From a statistical point of view, governing bodies must develop their data gathering and management operations, populating those metrics with strong, reliable data against which the world can measure its progress with confidence. In a large sense, technical interoperability is not the problem,

the institutional aspects of how to get various stakeholders, and the people who have an interest and capability to solve the data puzzle and work together effectively, is the biggest challenge.

The ideas and solutions presented in this book address the SDGs' connectivity dilemma and raise thought-provoking discussions from experts around the world that will help us all work towards achieving the goal of implementing the SDGs. It is exciting to see that by simply bringing people and minds together creates a very positive dynamic, where not only real change can be made, it can be sustained for all. *Stefan Schweinfest*

Director, UN Statistics Division
UN-GGIM Secretariat

Foreword by Dr. Stuart Minchin:

I'm delighted to see this book "Sustainable Development Goals Connectivity Dilemma: Land and Geospatial Information for Urban and Rural Resilience" published as part of the extensive work being undertaken by the UN Global Geospatial Information Management Group of Experts (UN-GGIM) raising awareness and paving the path forward for a better future for all.

This is an exciting time for people in the geospatial industry, government agencies, private firms and global development organisations to work together to achieve the Sustainable Development Goals in a manner than facilitates data sharing and transparency.

We live in a time with unprecedented access to data and technology which gives us all an opportunity to deliver real impacts for all jurisdictions and citizens of the world through providing decision ready solutions that can help to make the world a better place.

This book brings together contributions from around the world and presents an approach towards an SDG Roadmap, with viable solutions for enhancing the connectivity and resilience of SDG efforts. The legal, policy and institutional components are discussed and enabling and technical tools are also presented.

I look forward to seeing how the methods and solutions presented in this book can be put into practice and how we, the geospatial community, can work together to address the global challenges we face.

Stuart Minchin
Chief Environmental Geoscience Division, Geoscience Australia
Australian Principal Delegate to UN-GGIM

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Preface

This book is the culmination of the hard work and extensive research undertaken by members of the UN Global Geospatial Information Management (UN-GGIM), its Academic Network and a selected practitioner, to address the challenges our world faces and build a better and more sustainable future for us all.

Both developed and developing countries require an expertise and guidance in geospatial data, methods, frameworks, tools and platforms that can provide reliable, timely and accessible geospatial information in order to progress informed decision-making and ultimately pave the path forward for implementing the Sustainable Development Goals (SDGs).

Achieving the SDGs across different communities and domains faces unique challenges. The solutions in this book not only present an approach towards an SDG roadmap, but also discuss the interconnection between SDGs, geospatial information, the legal, policy and institutional components, technical enabling tools and the way forward to address urban and rural resilience.

This book brings together the expertise of leading geospatial experts, scholars, industry actors, and policy-makers and their perspectives from their respective fields to examine the connection between SDGs, geospatial information, and urban and rural resilience. The themes and objectives of the book are in line with the critical challenges, gaps, and opportunities raised at all UN-GGIM Academic Network forums and events.

The authors in this book, from all around the globe, have worked together in hope of taking steps towards achieving the 2030 Agenda for sustainable development by the United Nations. We hope that together, we can build a resilient future, promote prosperity and make the world a better place, leaving no one behind.

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Acknowledgements

This book is the result of a collaborative initiative of the United Nations Global Geospatial Information Management (UN-GGIM) Academic Network, it's members and the wider geospatial community and practitioners. The book has drawn upon the presentations and outcomes of three UN-GGIM Academic Network Forums: "Secure Land Rights and Smart Cities – Making It Work for Sustainable Development" as part of the Seventh Session of the United Nations Committee of Experts on UN-GGIM in 2017, "The SDGs Connectivity Dilemma: Urban Settlements, Resilience, and Sustainability" as part of the Eighth Session of the United Nations Committee of Experts on UN-GGIM in 2018 and "A Sustainable and Resilient World: Capacity Building and Geospatial Research for Implementing the SDG", as part of the first UN World Geospatial Information Congress UNWGIC in China 2018. The main aim being, to provide interdisciplinary analysis and multi-sectoral expertise on the interconnection between the SDGs, geospatial information, the legal, policies and institutional components, technical enabling tools and the way forward to address urban and rural resilience.

The editor has been privileged to have been involved with the UN-GGIM Academic Network in a leadership role, enjoying the support of the Academic Network members and a vast number of researchers, practitioners and policy makers and geospatial engineers throughout the journey for the preparation of this book.

I would like to acknowledge and thank the contribution of over 40 chapter co-authors from different organisations and countries. I am deeply grateful for the outstanding support and valuable contributions of all participants and speakers of the UN-GGIM Academic Network three International Forums conducted between 2017-2018 as part of UN-GGIM events. In particular, I would like to thank the support of Mr. Stefan Schweinfest, Director of the UN Statistics Division, the UN-GGIM Secretariat Team including in particular, Mr. Greg Scott, Mr. Teo Chee Hai, Ms. Cecille Blake, and Ms. Vilma Frani for their support and facilitation.

I would also like to extend my sincere thanks to Dr Wael Zakout from the World Bank for his contribution to our forums which has led to this publication and his continuous encouragement and support.

I am grateful to the Taylor and Francis Group Press for their support and willingness to publish this work as Open Access, which allows all to use the experiences and research presented in this book to their own best advantage. In particular, I would like to express my sincere thanks to Ms. Irma Britton,

Senior Editor, Environmental Sciences, GIS & Remote Sensing CRC Press - Taylor & Francis Group for her contribution, continuous support and facilitation for publishing this book. I also like to thank Ms. Rebecca Pringle and the rest of the T&F publishing team for their professionalism during the preparation of this book.

Finally, I would like to thank the Department of Infrastructure Engineering and the research team at the Centre for spatial Data Infrastructures and Land Administration (CSDILA) for their support, and in particular special thanks to Dr Ida Jazayeri and Dr Farhad Laylavi from the Centre for their outstanding editorial assistance in preparation of this publication.

I hope this book can contribute to the future of our societies and help in achieving SDGs.

Abbas Rajabifard, Editor
Chair UN-GGIM Academic Network
2019

Biographies of Authors

Abbas Rajabifard is Chair of UN-GGIM Academic Network, and a Professor at the University of Melbourne and Director of the Centre for SDIs and Land Administration (CSDILA). He is an international land and geospatial policy and technological advisor, who has spent his career researching, developing, applying and teaching land administration and SDI to deliver benefits to both governments and wider society. His research is on enabling SDGs using spatial information, 3D urban land administration and cadastre, spatial urban data analytics and 3D platform for smart cities.

Greg Scott is the Inter-Regional Advisor for Global Geospatial Information Management in the United Nations Statistics Division, Department of Economic and Social Affairs. Greg provides high level strategic policy advice and leadership in the coordination and implementation of UN-GGIM initiatives with Member States and related International Organizations involved in national, regional and global geospatial information management.

Daniel Paez is a civil engineer with a PhD in Geomatics from the University of Melbourne. He has experiences working as a public official, university lecturer and private consultant. Currently he is a Senior Industry Advisor for the Centre for SDIs and Land Administration (CSDILA) at the University of Melbourne.

Maryam Rabiee is a researcher working on interdisciplinary approaches to sustainable development. Her work focuses on the Sustainable Development Goals and the social aspects of sustainability in the context of geospatial science, disaster management, and ICTs.

Katie Potts is a post-doctoral research fellow at the Centre for SDIs and Land Administration (CSDILA) at the University of Melbourne and has a background in land administration and disaster risk reduction, focusing on implementing land-related policies and land management strategies to create land security which is vital for the development of wealth and economic health, the privatization of land markets, and sustainable urban planning and land development.

Mika-Petteri Törhönen is a land tenure, policy and administration professional with 25 years of work experience from over 20 countries in Europe, Africa, Asia, Near East and Central America. Mika holds the position of Lead Land Administration Specialist at the World Bank's Global Land and Geospatial Unit. Before joining the Bank in 2011, Mika worked in FAO's Land Tenure and Management Unit in Rome.

Alvaro Federico Barra is a land administration/geospatial specialist at the World Bank in Washington DC. He joined the Bank in 2008 and is currently working on Land Administration/NSDI projects in Sierra Leone, Mozambique, Lebanon and Bosnia, leading a study about improving resilience and resilience impact of national land and geospatial Systems.

Ivelisse Justiniano is an Urban and Disaster Risk Management Specialist at the World Bank. Most of her work focuses on urban resilience, disaster risk assessment and mitigation, risk reduction strategies, land use, and geospatial technologies.

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Masood Varshosaz holds a PhD in Photogrammetry from University College London, UK. He is actively involved in various fields including close range photogrammetry, computer vision, panoramic modeling, and laser scanning.

Michael J. Starek is an Associate Professor in Geospatial Systems Engineering at Texas A&M University-Corpus Christi (TAMU-CC) and Director of the Measurement Analytics (MANTIS) Lab with the Conrad Blucher Institute for Surveying and Science. Starek holds a Ph.D. in Civil Engineering from the University of Florida and was formerly a National Research Council Postdoctoral Fellow of the U.S. Army Research Office in affiliation with North Carolina State University. His research focuses on the merging of geomatics, remote sensing, and geospatial computing for precise measurement and analysis of natural and built system dynamics.

Melanie Gingras is a Research Specialist and Manager for MANTIS Lab as well as a Physics Adjunct Professor for Texas A&M University at Corpus Christi (TAMUCC). She earned her bachelor's degree from the University of

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Gary Jeffress is a Research Professor at the Conrad Blucher Institute for Surveying and Science at Texas A&M University-Corpus Christi. He holds a Ph.D. in Surveying Engineering from the University of Maine, Master of Surveying Science (Geodesy) and Bachelor of Surveying degrees from the University of New South Wales, Sydney, Australia. He is a Registered Professional Surveyor in Texas and held surveying licenses in Maine and Australia.

Harlan J. Onsrud is a Professor of Spatial Informatics in the School of Computing and Information Science at the University of Maine. His research and teaching interests focus primarily on the analysis of legal, ethical, and institutional issues affecting the creation and use of digital databases and the assessment of the social impacts of spatial technologies.

Joep Crompvoets holds a chair on Information Management in the Public Sector. He is also secretary-general of the EuroSDR network, which is a not-for-profit European organisation linking national mapping and cadastral agencies with research institutes and universities for the purpose of applied research in spatial data provision, management and delivery.

Serene Ho is the Vice-Chancellor's Research Fellow (Urban Futures) at RMIT University (Australia), a Fellow at the Public Governance Institute at KU Leuven (Belgium), and an Honorary Research Fellow at the University of Melbourne (Australia). Her research examines the implications of disruptive geospatial technologies in terms of public management and social innovation.

Zhixuan (Jenny) Yang, is a lecturer in the School of Investment and Construction Management, Dongbei University of Finance and Economics (DUFE), China. She is currently working in the field of urban governance and real property management, conducting research projects of “3D city governance” and “smart cities in the perspective of SDGs”.

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life. He investigates approaches for leveraging 3D geospatial data and analytics in planning for future smart cities.

Josef Strobl is head of the Department of Geoinformatics - Z_GIS at the University of Salzburg and as a full member of the Austrian Academy of Sciences (ÖAW) chairs the ÖAW Commission for Geographic Information Science. He is leading international graduate programmes in Applied Geoinformatics as well as the UNIGIS network of distance education programs (www.unigis.net).

Denise McKenzie joined the OGC in 2012 and spends her time managing the Communication and Outreach program globally for the consortium. The program handles the planning and execution of marketing, communication and education to raise awareness and increase implementation of open geospatial and location standards by technology providers and users worldwide. Part of Denise's role is to oversee OGC Alliance Partnerships including representation at the United Nations Global Geographic Information Management (UNGGIM) committee.

Gottfried Konecny is an Emeritus Professor at Leibniz University Hannover. He has a world of experience across continents researching and publishing in the realm of geoinformation. He is one of the pioneers in the field and is considered one of the founding fathers of photogrammetry, remote sensing and topographic mapping.

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Deren Li is currently working at Wuhan University. He is a member for both the Chinese Academy of Sciences and the Chinese Academy of Engineering. He holds a doctorate degree from the University of Stuttgart in 1985. In 2012, the International Society for Photogrammetry and Remote Sensing awarded him as an Honorary Member.

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Chryssy Potsiou is teaching Cadastre, Land Management and Property Valuation at the School of Rural & Surveying Engineering of NTUA, Greece. She has been: member of the boards of the Hellenic Mapping and Cartographic Organization; Hellenic Association of Rural and Surveying Engineers; the Hellenic Societies for Photogrammetry and for Geographic Information Systems; FIG Commission 3 Chair (2007-2010); FIG Vice President (2011-2014); FIG President (2015-2018); UNECE Working Party on Land Administration (WPLA) bureau member (2001-2018) and Vice Chair (2019-2020). She has published 125 peer reviewed papers.

Mohsen Kalantari is a Senior Lecturer in Geomatics Engineering and the Associate Director for Research at the Centre for SDIs and Land Administration (CSDILA) at the University of Melbourne. He has a proven track record of achievements in several national and international research grants and consultancy projects in the areas of spatial data infrastructures, land administration, and the nexus of geographic information systems (GIS).

Muyiwa Agunbiade is a Senior Lecturer at the Department of Urban and Regional Planning in the Faculty of Environmental Sciences, University of Lagos, Nigeria where he lectures GIS, Spatial data infrastructure and Land Administration courses. After completing undergraduate training in environmental design and management from the Obafemi Awolowo University in Nigeria, he earned master's degrees in both urban planning and Geographic Information Systems at the University of Ibadan, and a doctorate in Spatial Data Infrastructure from the Faculty of Infrastructure Engineering, University of Melbourne, Australia.

Yiqun (Benny) Chen is a Research Fellow in the Centre for SDIs and Land Administration (CSDILA) and the Centre for Disaster Management & Public Safety (CDMPS) at the University of Melbourne. He has a broad research interests including GIS visualisation, spatial analysis, disaster management, geo-intelligence, decision-support system, agent-based modeling and location-based services.

Akindeju Oluyemi, is a Lecturer and a PhD staff candidate in the department of Urban and Regional Planning of the University of Lagos, holds BSc (2005) and MSc (2010) degrees in Urban and Regional Planning from the University of Lagos, with research interest in Urban Morphology, Science of Cities, Complexity Modelling and Environmental Planning.

Oluwafemi Olajide is a lecturer at the Department of Urban and Regional Planning in the Faculty of Environment Sciences, University of Lagos,

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Maria Antonia Brovelli is a Professor of GIS and Digital Mapping at Politecnico di Milano. She is the chair of ISPRS WG IV/4 "Collaborative crowdsourced cloud mapping (C3M)", member of ESA ACEO (Advisory Committee for Earth Observation); chair of the "Capacity Building WG" of the UN Open GIS Initiative, Deputy-Chair of the UN-GGIM Academic Network. One of her main interest is in open source geospatial science and technology, where she is playing a worldwide leading role.

Serena Coetzee is Professor and Head of the Department of Geography, Geoinformatics and Meteorology, and Director of the Centre for Geoinformation Science at the University of Pretoria. Her research focuses on the ever-increasing volumes of geographic information and the challenges of making the information findable, accessible and usable. The research is of an interdisciplinary nature, mainly in geoinformatics and computer science.

Codrina Maria Ilie is a technical geographer, dividing her time between the Technical University of Civil Engineering of Bucharest and, a Bucharest based SME. She is actively working in developing geospatial data services incorporating data from non-traditional sources, such as the open data initiative. Her work at the Technical University of Civil Engineering focuses on geodata standardization and interoperability in groundwater data management.

Hamed Olfat is a Senior Research Fellow in the Centre for SDIs and Land Administration (CSDILA) at the University of Melbourne and is responsible for coordinating the ePlan project in Victoria. His main areas of research include 'electronic land administration', '3D digital cadastre', 'spatial data infrastructure', and 'data discovery'.

Davood Shojaei leads the 3D digital cadastre research at Land Use Victoria in Melbourne. He has extensive experience over the last 15 years in designing and implementing a variety of projects, ranging from GIS, cadastre and BIM, to 3D visualisation. Davood completed his PhD on 3D cadastre at the University of Melbourne in 2014. He is currently working with the ePlan team to develop and implement digital cadastre services in Victoria, Australia.

Part I

Setting the Scene

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1

Sustainable Development Goals Connectivity Dilemma

Abbas Rajabifard

Centre for SDIs and Land Administration, The University of Melbourne, Australia

1.1 Introduction

In the context of United Nations Global Geospatial Information Management (UN-GGIM) and the development of Sustainable Development Goals (SDGs), *recalling* Economic and Social Council resolution 2011/24, of 27 July 2011, which established the UN-GGIM to provide a forum for coordination and dialogue among Member States, and 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. Further also *recalling* the establishment of the UN-GGIM Academic Network in July 2016 as a strategic research and training arm for UN-GGIM to assist members, and *recalling* Economic and Social Council resolution 2016/27 entitled 'Strengthening institutional arrangements on geospatial information management' of 27 July 2016, in which the Council acknowledged the considerable achievements of the Committee of Experts including: its contribution to the strengthening of geospatial information management capacities and utilization 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 Global Agenda for Sustainable Development, the Sendai Framework, and other global development agendas within the purview of the United Nations.

Also *recalling* General Assembly resolution 70/1 entitled 'Transforming our World: The 2030 Agenda for Sustainable Development' of 25 September 2015, which recognizes the need for new data acquisition and integration approaches to improve the availability, quality, timeliness and disaggregation of data, and the use of a wide range of data, including earth observations and geospatial information, to support the implementation of the new development agenda at all levels, while ensuring national ownership in supporting

and tracking progress; noting the opening statement of the Secretary-General at this Congress, in which he emphasized that our expertise and guidance in geospatial data, methods, frameworks, tools, and platforms is urgently needed, and that 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; and also noting further that United Nations World Geospatial Information Congress (UNWGIC) in November 2018, which has provided a convening, participatory and inclusive environment to enhance the communication, understanding, knowledge and application of geospatial and land information management, to discuss the policy relevance and challenges to advance geospatial science and technology, promote the creation and sharing of more reliable geospatial data, and to enhance value-added applications and services to address local, regional and global challenges; all have highlighted the needs for a roadmap facilitating the achievement of SDGs implementation through the lens of Geospatial information.

With this in mind, this book will provide interdisciplinary analysis and multi-sectoral expertise on the interconnection between the SDGs, geospatial information, the legal, policies and institutional components, technical enabling tools and the way forward to address urban and rural resilience.

Urbanization, natural and human-induced disasters, migration, and technological advancements are among some of the most potent forces that are increasing the connectivity and complexity of the challenges highlighted in the SDGs. Achieving the SDGs across different communities and domains will require the use of geospatial information to overcome challenges such as land rights, food production, disaster risk reduction, safe human settlements, and other social, economic, and environmental issues at local, national, and global levels. Geospatial information and technologies are particularly critical to strengthening urban and rural resilience, where economic, agricultural, and various social sectors intersect.

The SDGs dependency on geospatial information and enabling technologies are mainly due to the primary roles that 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. 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 United Nations 2030 Agenda, 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 of Things (IoT), 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. Examining the SDGs from a geospatial lens will ensure that the challenges are addressed for all populations in different locations, leaving no one behind.

In addition, identifying the gaps and opportunities in understanding the connectivity between different elements of sustainability and resilience requires input from different disciplines and sectors.

1.2 Addressing SDGs and Land Tenure: The Need for a Roadmap

The achievement of the SDGs for all communities and jurisdictions require a comprehensive roadmap that encompasses all dimensions of data infrastructure, social, economic, environmental and governance ecosystems.

With this in mind, this book provides interdisciplinary analysis and multisectoral expertise on the interconnection between the SDGs, geospatial information, the legal, policies and institutional components, technical enabling tools and the way forward to address urban and rural resilience. In addition, we discuss the security of tenure targets embedded in the SDGs. We stressed the importance of the land administration and surveying profession owning the SDGs selected targets such as Target 1.4 on ensuring that all men and women have equal rights to land and other forms of property by 2030. Very few countries actually know what their baseline on the security of tenure is and even fewer have a program or plan in place for achieving the target by 2030.

Similarly and in a broader context, Goals 1, 2, and 5 of the SDGs have designated targets linked to land tenure rights signify the obligation of incorporating land administration in the process of building sustainable and smart cities for all. Therefore, surveyors and geospatial practitioners should work to change this globally and help countries to adopt national programs on security of tenure while addressing SDGs Goals, Targets and Indicators.

The UN-GGIM 2017-2021 Strategic Framework recognizes the necessity of integrating geospatial information in process of achieving the SDGs and developing future cities. Strengthening local, national, and global cooperation to foster the integration of legal and organizational frameworks including the SDGs, UN-GGIM 2017-2021 Strategic Framework, Sendai Framework, and Habitat III Urban Agenda will positively impact disaster management, development of adequate policies and regulations, climate action, efficient urban planning, and good institutional governance.

The availability of effective and efficient land administration—and its economic, social, and environmental implications—remains a problem worldwide, especially in developing countries where mature land administration systems and formal land registration systems are not available. Therefore, spatial in-

clusion, secure land rights, and sustainable land use are all major challenges of rapid urbanization that public and private sectors need to address in the development of future smart cities.

Considering this situation, the UN-GGIM Academic Network recognizes the importance of promoting and sharing data acquisition and integration approaches, legal and policy instruments, institutional management models, technical solution and standards, interoperability of systems and data, and access to quality and timely data. As a result, the Academic Network aims to work in the direction resolution 2016/27 of the Economic and Social Council (ECOSOC) by promoting the sharing of geospatial data, enhancing capacity building, and inter-institutional cooperation for sustainable development, disaster risk reduction, and policymaking.

With the above context in mind, the large-scale migration from rural to urban areas, and between countries, affects sustainable development at local, national, and regional levels. In order to identify gaps and opportunities to strengthen urban and rural resilience to global challenges, the book will draw upon the discussions and presentations and outcomes of three UN-GGIM Academic Network Forums: "*Secure Land Rights and Smart Cities – Making it Work for Sustainable Development*" as part of the Seventh Session of the United Nations Committee of Experts on UN-GGIM in New York in 2017, "*The SDGs Connectivity Dilemma: Urban Settlements, Resilience, and Sustainability*" as part of the Eighth Session of the United Nations Committee of Experts on UN-GGIM in New York in 2018, and "*A Sustainable and Resilient World: Capacity Building and Geospatial Research for Implementing the SDG*", as part of the first UN World Geospatial Information Congress-UNWGIC in China 2018. Therefore, in the context of SDGs and urban and rural resilience, the main objective of the book is to bring together the expertise of leading geospatial experts, scholars, industry actors, and policy-makers and their perspectives from their respective fields to examine the connection between the SDGs, geospatial information, and urban and rural resilience.

1.3 Book Structure and Overview

This book is structured in 5 parts, and the themes and objectives of the book are in line with the critical challenges, gaps, and opportunities raised at all UN-GGIM events and UN-GGIM Academic Network forums. Three main themes are the following:

- the role of geospatial information and data infrastructures and services in achieving the SDGs goals;
- the interactions and relations between various elements of the SDGs; and

- the significance of geospatial information in strengthening community, infrastructure, and institutional resilience.

The three main objectives of the book are the following:

- provide interdisciplinary analysis and multi-sectoral expertise on the interconnection between the SDGs, geospatial information, and urban and rural resilience;
- examine how geospatial information will support and inform inclusive and even urbanization, resilient development, and the SDGs; and
- present roadmaps for a more holistic approach to integrating geospatial information and technologies in the implementation of the SDGs.

The rest of this section provides a brief overview of the parts and chapters of this book (Figure 1.1).

Part 1. Setting the Scene

Part 1 provides a context and background to the SDGs connectivity dilemma, with a high level description of what SDGs mean and the impacts of spatial enablement. This part comprises of four chapters, beginning with this Chapter 1, which outlines the context and objectives of the book and discussion about the needs of a roadmap towards achieving SDGs, together with an introduction to the following chapters. Chapter 2 by, Greg Scott and Abbas Rajabifard, put forward the SDGs Roadmap. The chapter addresses the 2030 Agenda for Sustainable Development, anchored by 17 Sustainable Development Goals (SDGs), providing a transformative and integrated approach to sustainable development. With emphasis on measuring and monitoring development progress with reliable policy, science, technology and especially data, the 2030 Agenda presents all countries and the global policy community with a set of significant development challenges that are almost entirely geographic in nature. The chapter also discusses policy challenges, including the strategic leadership, understanding and awareness of national geospatial information policy, frameworks and associated implementation roadmaps. As a tangible means to support the implementation of the SDGs, Greg Scott and I present and discusses the key components of a geospatial roadmap for countries to develop and strengthen their institutional arrangements in national geospatial information management, to bridge the geospatial digital divide, and to measure and monitor development progress. Therefore this chapter will focus on a roadmap towards a sustainable and resilient future for all.

With this, Chapter 3, by Daniel Paez, then addresses the marriage of opposites: strategies for public and private sectors working together in land tenure reform projects that support SDGs. Strategies are presented in this chapter can be used during the design and implementation of future land reform projects both in developed and developing countries as part of empowering SDGs. In order to highlight the role of geospatial information and their ability

to enable the environment further, Chapter 4 by Maryam Rabiee addresses the social, economic, and environmental impacts of spatial enablement when spatially enabling the SDGs. Ready and timely access to spatial information is critical to making informed decisions on economic, environmental and social issues. This chapter aims to present the significance of spatially enabling the SDGs and the opportunities it provides for the seventeen goals. The chapter investigates the social impact of spatial enablement for the SDGs and ends with a discussion on land, the driving force of spatial enablement for the SDGs.

FIGURE 1.1
Overview of the Book

Part 2. Enhancing SDGs Connectivity and Resilience

In the context of SDGs connectivity, this part examines how geospatial systems can support disaster resilience, risk reduction and improved mapping for better SDG connectivity and better management. As discussed earlier,

geospatial information can help locate the challenges of communities in different regions more visible and integrating geospatial data with other available data can assist with addressing the 'where' component of different social, economic, and environmental challenges. To highlight the significance of geospatial information in strengthening community, infrastructure, and institutional resilience, this part will present ways, in which geospatial information can assist with narrowing the connectivity gap. This part comprises three chapters, beginning with Chapter 5, where Abbas Rajabifard, Mika Petteri Törhönen, Katie Potts, Federico Barra and Ivelisse Justiniano, address the concept of leveraging National Land and Geospatial Systems for improved disaster resilience. In the context of SDGs this chapter is based on a World Bank flagship project let by the authors of the chapter to present a roadmap for exploring the role of land and geospatial information, the function and responsibility of the institutions that govern the data, and the resulting impact that this data has on the overall resilience of society to disasters. Following this in Chapter 6, Saeid Pirasteh and Masood Varshosaz present geospatial information technologies that can support the UN-GHIM in its efforts in disaster risk reduction, mitigation and resilience, particularly those due to earthquakes. The final chapter in Part 2 (Chapter 7), by Michael J. Starek, Melanie Gingras, and Gary Jeffress explores the application of unmanned aircraft systems as as example of tools for coastal mapping and resiliency. The information and applications presented are applicable to a variety of UN SDGs including sustainable land use for "Life on Land" and sustainable agriculture for crop security and "Zero Hunger".

Part 3. Supporting SDGs: Legal, Policies and Institutional Components and Capacity Building

This part discusses the sustainability and resilience challenges that are directly tied to legal, policy, and institutional capacities to make inclusive and effective decisions that positively impact our communities. The Part 3 comprises of five chapters to address legal and institutional gaps and requirements for sustainability and its impact on inclusivity. To begin, Harlan Onsrud puts forward the legal and policy paths for effective sustainable development in Chapter 8. He discusses the requirements and fundamental relationships between legal and policy framework to support SDGs. Next, in Chapter 9, Joep Crompvoets and Serene Ho discuss the issues that have arisen from the UN-GGIM during the sessions over the past 6 years, highlighting the need for developing a framework for national institutional arrangements in geospatial information management. This chapter will provides the rationals and the approach for the development of institutional arrangements in support of geospatial information management as an essential enabler for SDGs. Following this, Chapter 10 by Serene Ho discusses the considerations for institutional interconnectivity. The institutional challenges around the coordination and collaboration in the public sector are reviewed, and a discussion on potential strategies for progression in this space is presented. In Chapter 11, Zhixuan

Yang and Abbas Rajabifard discuss implementing SDGs for Smart Cities as an example to establish the theoretical framework by exploring key components to observe the implementable structure and action of SDGs at the city level. Particularly, the chapter aims to highlight the fundamental foundations beyond digital tools to achieve SDGs. In chapter 12 Soheil Sabri and Abbas Rajabifard explore the UN-Habitat's initiatives in adoption and localising the SDGs through defining the New Urban Agenda (NUA) 2030. They provide a historical account on how the global urbanisation started to be considered as a threat and ended up to be a potential development tool for the future generation established by the NUA. They also explain the Action Framework for Implementation of NUA (AFINUA) developed by the UN-Habitat to localise the implementation, measurement, and monitoring the SDGs and other associated indicators formulated through City Performance Initiative (CPI). This chapter also draws links between spatial enablement concepts and principles and the key elements of AFINUA. And finally, Chapter 13, by Josef Stobl discusses the development of "Brainware" for SDI. This chapter highlights the importance of academic education in geospatial technologies for building and maintaining the brainware components that will make the SDG framework successful across human societies.

Part 4. Enabling Tools and Technical Components

Part 4 addresses technology and tools that can assist with monitoring and measuring progress at different levels of governance and across different regions. There are three chapters in this part, beginning with Chapter 14, contributed by a joint standards team from ISO and OGC, Denise McKenzie et al. addressing the role of geospatial information standards for sustainable development. This is followed by Chapter 15, where Abbas Rajabifard and co-authors describe a new research initiative that sees the development of an SDI to support urban analytics and urban research capabilities focused on Australian cities, called Urban Analytics Data Infrastructure (UADI). The UADI provides opportunity for multi-disciplinary, cross-jurisdiction, national-level analytics, which appeals the requirements of SDGs and potentially can be scaled up to be used by other nations. The chapter explains about the design of UADI architecture, which seeks to provide the urban research community with a digital infrastructure that responds to current challenges related to data access, sharing and driving the SDG indicators. Chapter 16 by Gottfried Konecy discusses technical enabling tools for data acquisition and maintenance of topographic data of urban and high mountain areas. This chapter explores data resolution, global progress in mapping, new mapping alternatives and how these relate to achieving SDGs. The last chapter in this part by Huayi Wu, Xi Li, Deren Li, addresses night-light remote sensing, a tool which can be used towards achieving SDGs. Case studies are presented showing how night-light remote sensing can plat a very important role in the assessment of humanitarian disasters.

Part 5. SDGs Perspectives

This part of the book looks at what the current state of play is for SDGs around the world, and specific case studies and cases are discussed in four chapters. It begins with Chapter 18, where Chryssy Potsiou brings together a wealth of knowledge as a leader of the field, compiling over 20 years of research, in cooperation with the FIG, the World Bank, UNECE and government agencies around the world to address why and how informal development should be formalized quickly, inclusively and affordably. Chapter 19 by Muyiwa Agunbiade, Olajide Oluwafemi, and Oluyemi Akindeju gives a perspective from Nigeria, Africa. This chapter discusses SDGs connectivity by exploring the nature of interlinkages between the SDGs from the lens of geospatial information and geospatial data infrastructure. It also focuses on evolving an integrated framework towards achieving SDGs in developing economies. Chapter 20 by Maria Antonia Brovelli, Maria Ilie Codrina and Serena Coetzee, discusses Openness and Community Geospatial Science for monitoring SDGs, giving an example from Tanzania for SDGs Goal 9. The authors, focus on these two aspects: openness and community geospatial science, presenting concepts and examples of open data and open software with reference to citizen science and volunteered geographic information. The final chapter in this part, by Hamed Olfat and Davood Shojaei examines the Case Study of Victoria, Australia for modernizing land administration systems to support the SDGs.

Sustainable development and resilience are continuous paths towards a better future for all. We must ensure that our contribution to this domain of knowledge has long-term impacts towards leaving no one behind.

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SDGs Roadmap

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This chapter presents and discusses the major components that will assist our efforts in charting a geospatial roadmap towards the implementation of the SDGs. These being: the goals, targets and global indicators; the role of geospatial data and enabling technologies; bridging the geospatial digital divide; and a national strategic geospatial information policy framework.

2.1 Introduction

In July 2011, recognizing the urgent need to take concrete action to strengthen international cooperation in the area of global geospatial information management, the United Nations Economic and Social Council (ECOSOC) established the United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM). As the apex intergovernmental mechanism for geography, UN-GGIM makes joint decisions and sets directions with regard to the production and use of geospatial information within national, regional and global policy frameworks; promotes common principles, policies, methods, mechanisms and standards for the interoperability of geospatial data and services; and provides a platform for the development of effective strategies on how to build and strengthen national capacity concerning geospatial information, especially in developing countries. 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 [27].

In the past nine years, concerted efforts have been made by UN-GGIM to increase the visibility and awareness of the role of geospatial information, as an essential integrative tool to monitor and measure sustainable development, to policy and decision-makers and the diplomatic community. To this end, in July 2016, following a five-year review of UN-GGIM, ECOSOC adopted resolution 2016/27 on strengthening institutional arrangements on geospatial information management, in which it recognized that UN-GGIM had operated effectively and was well placed to continue to contribute more to the work of the United Nations. The Council 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'. It also stressed the need to strengthen the coordination and coherence of global geospatial information management, in capacity-building and norm-setting, particularly pertaining to the 2030 Agenda, the Sendai Framework, and other global development agendas within the purview of the United Nations [20].

Substantial progress is being made by UN-GGIM 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 organizations and researchers to analyze, model, monitor and report on sustainable development, disasters, climate change, and other global concerns" [29].

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" [31].

Geospatial information and enabling technologies have emerged as major contributors to economic and digital transformation in many countries, including in the areas of e-government, e-service and e-commerce. The global geospatial industry is witnessing unprecedented growth, driving innovation, knowledge, smart solutions, delivery platforms and a location-based information economy. But with more data and technology available than ever before, many developing countries have yet to have the 'opportunity' to interact with these rapidly emerging capabilities, as the democratization of geospatial information is not being equally shared. Geospatial data, leadership, knowledge and innovation is primarily still limited to the developed countries. While

technologies are evolving at a rapid rate, the commensurate capabilities, skills and opportunities in the developing countries are not.

Developing countries are still challenged by issues related to aspects regarding the management of data, and its closely coupled relationship with ICT, the Internet and other technologies. Further, there are institutional challenges related to coordination, leadership managing the value chain, fragmented implementation, diffused policy accountability, and then potentially the lack of skills, tools and mechanisms to properly manage the data supply chain and related technologies. 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.

The global geospatial community still has much work to do in raising awareness of the value and benefits of geospatial information at the policy level, liberating it from the traditional closed information silos at the technical level, integrating across the wider government sector, and establishing new alliances across a much broader and diverse stakeholder community. 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.

This chapter proposes a geospatial roadmap to enable SDGs implementation and, in addition, forms part of that process, addressing the lack of awareness and understanding of geospatial information particularly prevalent at the policy and decision-making levels in developing countries. Framed by the 2030 Agenda for Sustainable Development, and anchored by Figure 2.1, this chapter presents and discusses the major components that will assist our continued efforts in charting a geospatial roadmap towards the implementation of the SDGs. It will first contextualize sustainable development broadly, and its evolution towards the 2030 Agenda, before visiting the goals, targets and global indicator framework in detail. The chapter then describes the role of geospatial data and enabling technologies in contributing to the 2030 Agenda, before discussing 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, to connect to the vast amounts of data and technology, and accelerate human progress. The chapter will conclude with a national strategic geospatial information policy framework as a means to provide the national policy basis and roadmap for countries to develop and strengthen their national and sub-national arrangements in geospatial information management, as they attempt to measure and monitor progress towards the implementation of the SDGs.

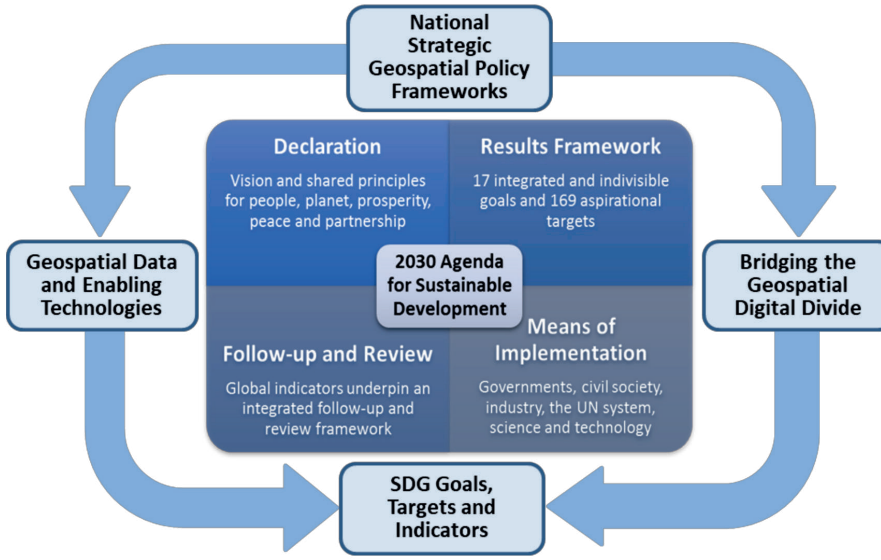

FIGURE 2.1
The major components in charting a geospatial roadmap towards the implementation of the SDGs.

2.2 Sustainable Development

Sustainable development concepts first appeared in the literatures in the early 1960s [24, 6], and quickly advanced to make interconnections between the environment, the economy and social well-being [4]; that the Earth had a finite capacity to sustain human civilization; and that population growth and resource consumption were unsustainable [5, 9, 10]. However, the mainstream theoretical framework and understanding of sustainable development evolved between 1972 and 1992, primarily through a series of international conferences and initiatives led by the United Nations [2].

The United Nations Conference on the Human Environment, convened in June 1972 in Stockholm, Sweden, was the first major international conference to discuss environmental sustainability issues at the global scale. The Conference marked a turning point in the development of international environmental politics, emphasizing that defending and improving the environment must become a goal to be pursued by all countries. 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" [12].

In December 1983 the United Nations General Assembly (General Assembly) established the World Commission on Environment and Development to formulate long-term environmental strategies for achieving sustainable development. In April 1987 the Commission produced the landmark report "Our Common Future" which advanced the understanding of global interdependence and the relationship between economics and the environment, and 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" [32]. The General Assembly adopted Our Common Future in August 1987, giving sustainable development political salience, and in June 1992 global leaders laid the foundations for its global institutionalization at the 'Earth Summit', the United Nations Conference on Environment and Development in Rio de Janeiro, Brazil. The Earth Summit adopted the Rio Declaration on Environment and Development, and Agenda 21 – a global plan of action for sustainable development [13].

Twenty years on, the United Nations Conference on Sustainable Development, or Rio+20, was convened in June 2012 in Rio de Janeiro. Rio+20 was pivotal in that it sought to initiate the process for a new development agenda for the future to supersede the Millennium Development Goals (MDGs). The focused political outcome document "The Future We Want" [14] 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. The Future We Want captured two critical 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 recognize the importance of comprehensive hazard and risk assessments, and knowledge- and information-sharing, including reliable geospatial information" and in the area of means of implementation – technology: "We recognize the importance of space-technology-based data, in situ monitoring and reliable geospatial information for sustainable development policymaking, programming and project operations" [14].

These efforts culminated in September 2015 when the General Assembly adopted "Transforming our World: The 2030 Agenda for Sustainable Development" [19], a universal development agenda for all countries and stakeholders to use as a blueprint for action. The 2030 Agenda is an agreed global and united development policy to guide the way 'all countries' collectively manage and report on the social, economic and environmental dimensions of people, planet and prosperity. With an overarching imperative of 'leaving no one behind', this transformative Agenda requires an integrated and inclusive approach to sustainable development. With considerable emphasis on coun-

tries being able to measure and monitor progress with reliable policy, science, technology and especially data, the broad and aspirational nature of the 2030 Agenda has ushered in a new era in thinking about and approaching sustainable development. It has determined a set of 17 SDGs and 169 targets, and defined a process to measure and monitor implementation through a global indicator framework (presently with 232 global indicators) that is 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. Importantly, the 2030 Agenda intrinsically captures specific and separate global United Nations system outcomes (Figure 2.2) for small island developing States [15], disaster risk reduction [18], financing for development [16], climate change [17], a new urban agenda [20] and oceans [21].

FIGURE 2.2
Overarching broad and universal global development policy agenda accepted by all countries during the 2014 – 2017 period. The 2030 Agenda for Sustainable Development provides the main means and mechanisms for implementation and measuring and monitoring progress through to 2030.

2.3 Goals, Targets and Indicators

The 2030 Agenda presents the global policy community with a set of 17 SDGs – significant development challenges that are almost entirely geographic in nature. It specifically demands the need for new data acquisition and integration approaches, including to exploit the contribution to be made by geospatial information and Earth observations to support the implementation of the SDGs, targets and global indicators. Further, it has articulated the need for counties 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