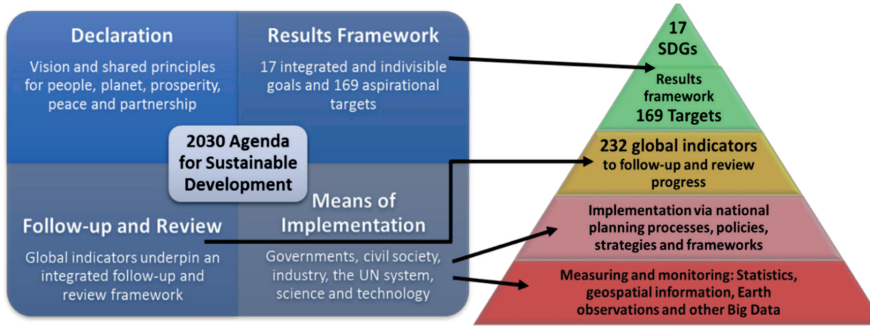

FIGURE 2.3
The 2030 Agenda is an integrated plan of action structured in four main parts: (i) a vision and principles for transforming our world as set out in the Declaration; (ii) a results framework of 17 SDGs and 169 targets; (iii) a means of implementation through governments, society and global partnership; and (iv) a follow-up and review framework of 232 global indicators. Any national SDG implementations will be sub-optimal without strategies and frameworks to integrate geospatial information and other data into the measuring, monitoring and reporting processes.

contexts ([19], Goal 17.18). Meeting these new data requirements is already proving difficult for the most advanced countries, but the 2030 Agenda further demands that by 2020 – in less than 2 years' time – this enhanced data availability is able to support and address the capacities and capabilities of developing countries, particularly African countries, least developed countries, small island developing States, and land-locked developing countries. For these 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.

As indicated in Figure 2.3, the 17 SDGs of the 2030 Agenda 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 aspirational targets provide the detailed and actionable objectives for governments to measure progress through to 2030. Each country will set its own national targets, guided by the global level of ambition, and will also decide how these targets should be incorporated into national planning processes, policies and strategies. While the 17 SDGs and 169 targets provide the overall policy and results framework for the 2030 Agenda, in terms of a robust and annual follow-up and review mechanism for its implementation, it is the global indicator framework where the data acquisition, integration and disaggregation is most needed.

The task of determining the global indicator framework was given to the

United Nations Statistical Commission. In 2015 the 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 national governments can consistently monitor achievement on, and report progress towards, each of the 169 targets. In July 2017 the global indicator framework was adopted by the General Assembly and comprises an initial 232 indicators, which will be reviewed from time to time and especially in 2020 and 2025.

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. Through this process, statisticians now better understand 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. This information integration is important, as the indicator framework will be the primary conduit to guide and inform Member States, based on individual national circumstances, on how they measure, monitor and report on the SDGs and related targets in the years to come. That said, determining the indicators was just the beginning, as they need to then be appropriately interpreted and implemented via national planning processes and frameworks, and guided by robust metadata and multidimensional data needs (Figure 2.3).

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. We still need to democratize the enabling technologies and liberate the associated data 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 mapping 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.

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 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 realizing 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" [22]. 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.

2.4 Geospatial Data and Enabling Technologies

Disruptive technologies are emerging and 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 digitization in new and unanticipated ways [7]. The concepts and expectations for the rapidly growing global interconnectivity and information societies are being underpinned by both digital disruption and digital transformation – enabling a modern information economy to prosper. 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 downside of the technology innovation trend is that the lack of robust digital infrastructure, including Internet connectivity and ICT infrastructure, are still 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 capitalize 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 artificial intelligence (AI)

and the Internet of things (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 [11].

The corresponding huge growth in the generation of data has meant that governments now realize 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 modernize and digitalize public sectors, and that they support new ways of working and creating public value [1]. 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 [8]. 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 [28, 30]. 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 [25]. 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 behavior and expectations [3].

Through technology, the potential of geospatial information has rapidly advanced and has now reached a level of maturity that allows this information flow to make a central contribution to the integration of information for many of the current social, economic and environmental challenges facing the world. Scott and Rajibafard (2017) introduced a general integrative sustainable development 'data flow' framework for national information systems to capture the required data elements [25]. It comprises a mix of national data that 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. Working from the base of Figure 2.4, the building blocks of the data flow framework are as follows:

1. The local to national real-world 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 small island developing States, limited capabilities and resources, including the means to even understand these conditions and their implications, will initially remain a significant capacity challenge;

2. Comprises the many and varied mix of fundamental baseline data resources and inputs, including new data collections that will be required. Many of these may need to be "repurposed" or significantly improved in order to adequately measure and contribute to the determined national indicators;

3. The national information systems that exist within countries will provide the means to ensure access to high quality, timely and reliable data that are structured, organized and managed, ideally in an interoperable and standards-based manner;

4. The national data are then 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. Such data will provide the SDG metrics for measuring and monitoring progress;

5. The National Statistical Offices will then undertake and finalize the official aggregation and integration into national country indicators, ensuring data integrity and validation;

6. The National Statistical Offices, and in collaboration with specialized United Nations agencies where appropriate, would then provide the final national indicators to the United Nations Statistics Division to be compiled into the global indicator framework 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. Initially as the 169 aspirational global targets; and

8. Finally as the 17 universal SDGs. It is expected that these processes will occur on an annual basis and be formally reported through the annual Sustainable Development Goals Report.

Regardless of logical synergies and linkages over a long period of time the reality is that even today, in a highly data and technology driven global environment, there has been very little connection and fusion between sustainable development and geography, geospatial information and NSDIs at either the political or the technical level. Now that real data is needed to measure and monitor and make evidence-based decision-making, the gaps and the lack of

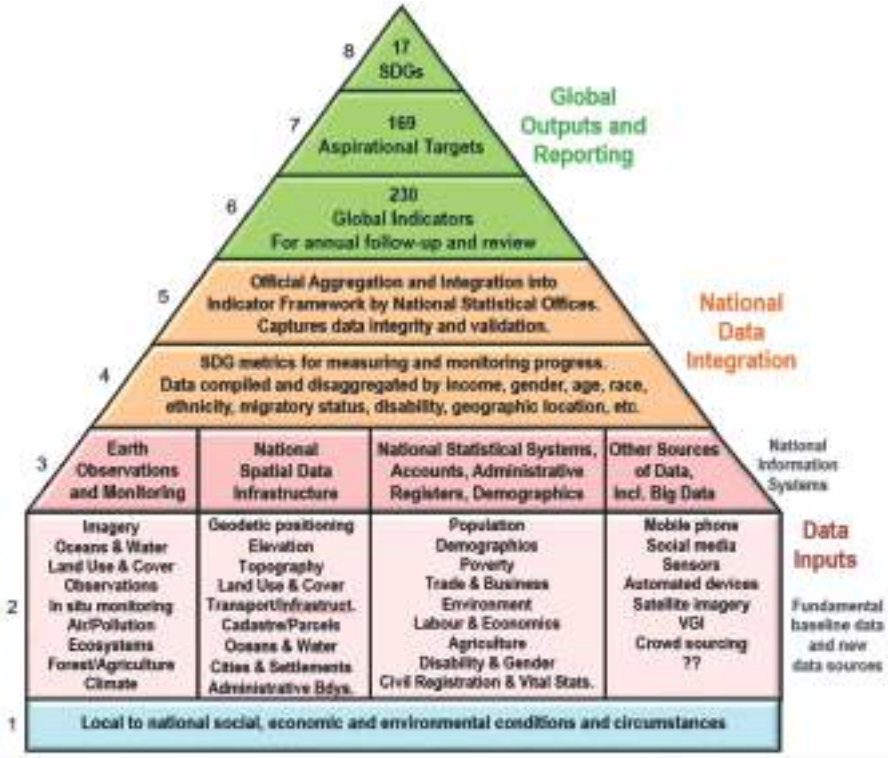

FIGURE 2.4
A general national information systems sustainable development 'data flow' framework that provides the building blocks and processes for any given country to measure and monitor the SDGs from local real-world conditions through to global harmonised reporting [25].

these connections are becoming apparent. 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.

2.5 Bridging the Geospatial Digital Divide

Although today's technology makes it possible to collate the data we need 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. An urgent transformational change in both thinking and ap-

proach is required – a digital transformation – which is simple in theory, but complex in implementation.

For developed countries, achieving digital transformation is still exacerbated by the lack of awareness and understanding of the role of geospatial information and enabling technologies at the policy and decision-making levels. For developing 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 and to orchestrate transformational change. They are yet to bridge the 'digital divide' before contemplating increased awareness and understanding of geospatial information. For these countries, exploiting the new science, data, technologies and tools to support the implementation of the SDGs compounds the problem. There is a need to extend well beyond the digital divide; 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. Although not yet being realised, these real needs bring with them real opportunities for developing countries to raise the awareness and understanding of the role of geospatial information and enabling technologies at national policy and decision-making levels. Achieving sustainable development requires national geospatial policy and digital transformation, but now those developing countries that need it most do not yet know what these transformative technology enablers are able to provide, as they must first bridge the geospatial digital divide.

To illustrate the enormity of the growing data and technology gaps between the developed and developing countries, Scott and Rajabifard (2019 in press) expanded on these concepts further, discussing the digital divide and the fundamental data, skills and technology challenges facing developing countries in a global 'digital transformation' economy, particularly as they pertain to sustainable development [26]. They then introduced the 'geospatial digital divide', 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.

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. However, 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, the exact nature of the digital divide is both contextual and debatable. 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. But, as demonstrated in Figure 5, there are multiple layers of additional, and non-linear, criteria to consider. The first is the 'Digital Access Gap', which captures the primary enabling mechanisms

for overcoming the digital divide – people's and country'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 related device, and the material assets to pay for sustained connection to the Internet, the ongoing costs of certain subscriptions and necessary peripherals for use. Ironically, another key and influencing determinant not often considered is access to reliable electricity, without which there simply is no access to computers, ICTs and the Internet, and enjoyment of the subsequent opportunities and benefits.

The second, the 'Digital Adoption Gap', relates to users possessing the necessary skills to adopt and make use of ICT, computers and the Internet, and to take part in the information society. The digital divide is also a human skills and knowledge transfer divide. 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, opportunities and experiences of digital technology and its adoption.

The third is the 'Digital Value Gap' and is governed by the lack of uptake, benefits and realization 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, socioeconomic class (social inclusion), and geography. With respect to geography, these societal elements can be mapped further geographically when aspects such as rural versus urban and industrialized versus developing countries have an effect. Additionally, the broader overarching national social, political, and economic implications of the digital divide, including lack of opportunity to solve societal problems, for countries should be considered in the Digital Value Gap.

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. One explanation for the between- and within-country divides is that effective use of the Internet is a function of literacy. Hence, closing the digital divide points to the need to focus on basic and secondary education and digital literacy ([23], p. 73).

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 upon the criteria and gaps of the digital divide, there are a number of additional and critical 'gaps' that contribute to the 'geospatial' dimensions of the digital divide as also detailed in Figure 2.5 .

The 'Data Ecosystem Gap' relates to the access to, and exploitation of, data itself – the vast amounts of geospatial data, Earth observations, statistics

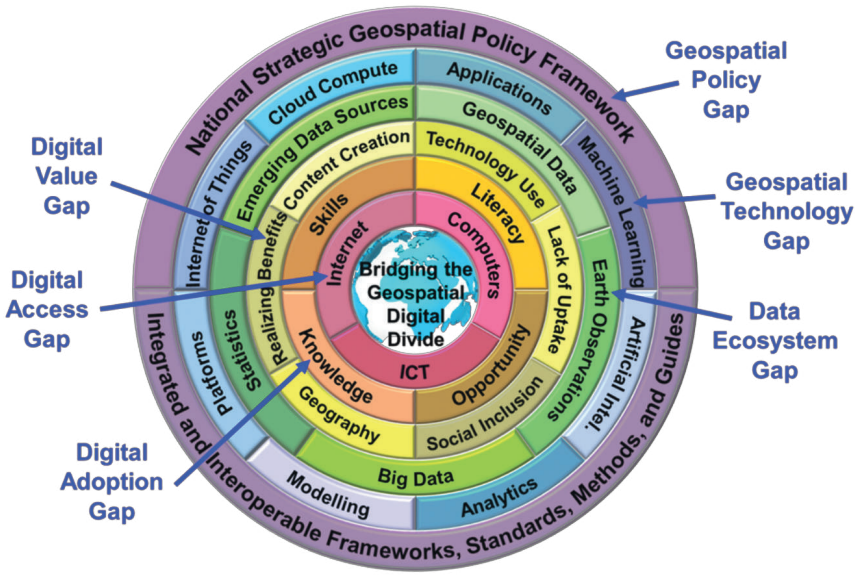

FIGURE 2.5
Building upon the criteria and gaps of the digital divide – the digital access, digital adoption and digital value gaps; there are a number of additional and critical 'gaps' that contribute to the 'geospatial' dimensions of the digital divide – the data ecosystem, geospatial technology, and geospatial policy gaps. Modified from [26].

(socio-economic and environmental), Big Data and the many new and emerging data sources. Much of the traditional 'fundamental data' would ideally reside within national information systems that exist within countries (Figure 2.4), providing the means to ensure access to high quality, timely and reliable data that are structured, organized and managed, ideally in an interoperable and standards-based manner [25]. 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.

The 'Geospatial Technology Gap' relates to the enabling, and increasingly growing, technology innovations that influence what we can do with the geospatial data ecosystem and how we manipulate its end-to-end use during its life-cycle. These include technology innovations like cloud storage and computing, the Internet of things (IoT), artificial intelligence (AI) and robotics, and machine learning; and delivery platforms, hardware, software, applications and interfaces that enable robust and repeatable modelling and analytics.

Finally, 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 overarching and strategic national framework. Therefore, and providing the means to 'implement' the bridging of both the digital divide and the geospatial digital divide, the 'Geospatial Policy Gap', as the outer and encompassing circle, is the key area in which all of the elements are able to be brought together and consolidated within a National Strategic Geospatial Policy Framework. 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?

2.6 A National Strategic Geospatial Information Policy Framework

Recognizing the importance of geospatial information is the first step towards overcoming barriers to implementation and bridging the geospatial digital divide. Scott and Rajabifard (2017) explored the challenges and opportunities to implement and integrate geospatial information into the global development policy agenda in a more holistic and sustainable manner at a national level [25]. The lack of policy and guidance, with commensurate critical gaps and connection points with national geospatial methods and frameworks, was seen as a visible impediment to developing countries and those most affected by the challenges and need to achieve national development. Bridging the geospatial digital divide – enabling people, processes, data and technology to implement national policy – requires a strategic policy realization of the impediments, but in such a way that they are able to be integrated into national strategies and arrangements; so that they can be anchored into national development agendas. A national strategic geospatial policy framework is able to provide this national guidance for developing countries as they attempt to measure and monitor progress towards the implementation of the SDGs.

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 overemphasized. To bridge the geospatial digital divide, countries will need to develop, strengthen and modernize 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