as a 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 would benefit all areas of government, and will also provide a consistent monitoring and reporting framework for sustainable development within the national policy context.

2.7 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.

2.7.1 Vision

The vision is that governments 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 plan for and provide better outcomes for future generations, and our collective aspiration to leave no one behind. Additionally, it recognizes that any national SDG implementations will be optimized using strategies and frameworks that integrate geospatial information into overall national social, economic and environmental development plans.

2.7.2 Mission

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.

2.8 Principles

In order to anchor the vision and mission to the national policy needs, and to the more specific goals, objectives, and priority actions, the Strategic Framework requires an enabling and collaborative environment where government organizations 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 realized 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 identifies seven principles or values. These principles represent the key characteristics and values that are to be used 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. The principles are the generic compass for supporting and implementing a policy and data framework, but allow for methods to be tailored to individual country needs and circumstances as required. Adherence to these principles will make complex collaboration possible among multiple agencies, 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 2.1.

2.9 Strategic Drivers

The strategic drives are aligned to the National Policy Context and will vary from country to country based on national priorities and objectives. They are not exhaustive and are provided as an initial set of global to national strategic objectives. With regard to the global development Agendas, many countries understand that the 2030 Agenda also captures the specific and separate global United Nations system outcomes as illustrated in Figure 2.2. All countries have aligned their national priorities and development outcomes to at least one of these global Agendas. 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.

TABLE 2.1
The seven Principles of the National Strategic Geospatial Information Policy Framework

PRINCIPLE 1 Strategic Enablement	The implementation of the Strategic Framework requires political and financial support, and should therefore align with and support government's strategic direction on issues such as economic growth, social well-being, job creation, 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 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 system, as well as providing clarity on roles and responsibilities.
PRINCIPLE 5 Integrative Solution	The implementation of the Strategic Framework is to be integrative in nature – and consider how people, organizations, systems, and legal and policy structures work together to form an effective and holistic system for managing geospatial information and its use.
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 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, prioritization 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.

2.10 Goals

To achieve the overarching vision, the Strategic Framework identifies eight goals. The progressive achievement of these goals will move countries towards a future state where they have the capacity and skills to organize, 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 Strategic Framework are detailed in Table 2.2.

2.11 Strategic Pathways

The Strategic Framework is anchored by nine strategic pathways in three main 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. The objective of these strategic pathways is to provide the 'implementation roadmap' to guide governments towards implementing integrated geospatial information systems in a way that will deliver a vision for sustainable social, economic and environmental development. Although the strategic pathways are presented as separate elements, and recognizing that there are many aspects and dimensions to each individual pathway, it is intended that, when the nine strategic pathways are united as one, the Strategic Framework is connected, integrated and implemented. Figure 2.7 illustrates the nine strategic pathways surrounded by the many benefits that are able to be realized when implemented together.

It is important to note that the strategic pathways are able to readily leverage and build upon existing national NSDI information architectures, capabilities and methodologies. The traditional evolution of NSDIs have been seen as coordinated actions of nations and organizations that promote awareness and implementation of complimentary policies, common standards and effective mechanisms for the development and availability of interoperable digital geographic data and technologies to support decision making for multiple purposes. However, one of the weaknesses is that many NSDIs are still predominately data supply rather than data demand driven and are rarely designed to be strategic frameworks or respond directly to high priority societal policy issues [25].

As shown in Figure 2.7, the strategic pathways represent 3 levels of enabling geospatial maturity. Level 1 maturity (Governance and Institutions, Data, and Partnerships) broadly aligns with the requirements for a typical initial NSDI implementation. The Level 2 maturity (Legal and Policy, Standards,

TABLE 2.2
The eight Goals of the National Strategic Geospatial Information Policy Framework

GOAL 1 Effective Geospatial Information Management	Enabling geospatial information governance, policy and institutional arrangements that ensure effective geospatial information management, accommodate individual organizational requirements and arrangements, and that are aligned to national, regional 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 mindset across government, industry, academia, and private and community sectors.
GOAL 3 Integrated Geospatial Information Systems and Services	Geospatial information, including community information, is integrated as a national information system and service across the government sector and maximized for evidence-based policy and decision-making.
GOAL 4 Economic Return on Investment	An economic return on investment is realized through best practice management, and the exploitation and innovative use of integrated geospatial information.
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.
GOAL 7 Enhanced National Engagement and Communication	All stakeholder groups, and specifically high-level decision-makers and champions, are fully engaged in the value of integrated geospatial information for decision-making and socio-economic development.
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.

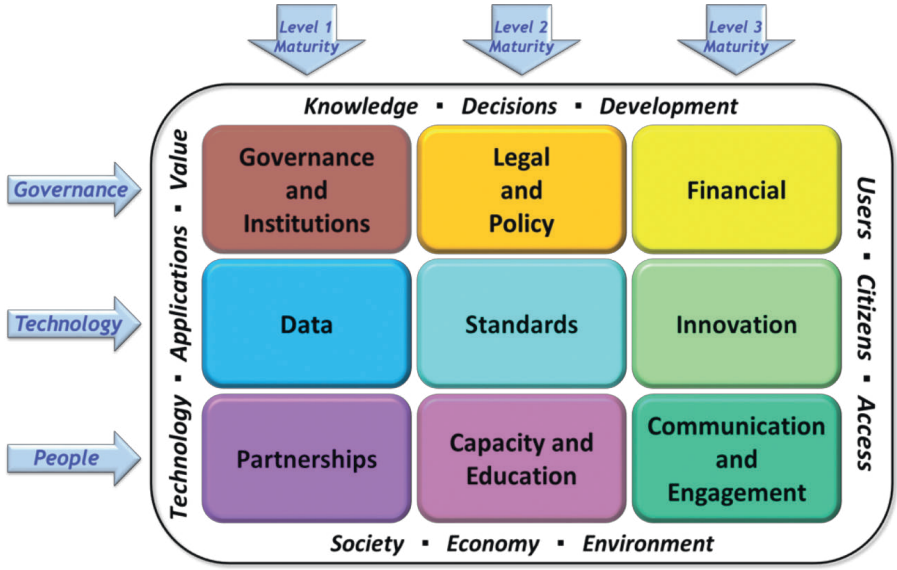

FIGURE 2.7
The nine Strategic Pathways of the National Strategic Geospatial Information Policy Framework

and Capacity and Education) represents what we would typically see as the 'enablers' for an advanced and mature NSDI implementation. Level 3 maturity (Financial, Innovation, and Communication and Engagement) represents the NSDI future state as an integrated 'on-demand' information knowledge infrastructure, in which we can 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 realized.

Although not all individually detailed in this chapter, the intent is that each of the nine strategic pathways are able to be explained and elaborated, along with specific detailed elements and objectives, as the particular set of tools that assist in guiding implementation of the Framework and achieving the required results. These objectives are provided at a high level in Figure 10.

TABLE 2.3: The specific objectives of the nine Strategic Pathways of the National Strategic Geospatial Information Policy Framework to assist countries in achieving the required results

STRATEGIC PATHWAY 1 Governance and Institutions	Establishes the leadership, governance models, institutional arrangements and a clear value proposition as a means to strengthen multi-disciplinary and multi-sectoral participation and commitment to achieving the Strategic Framework. The objective is to attain political endorsement, strengthen institutional mandates, and build a cooperative data sharing environment through a shared understanding of the value of the Strategic Framework, and the roles and responsibilities to achieve its vision. Good and consistent governance is critical in countries so that policies and institutional arrangements are able to be insulated and protected from political and administrative change.
STRATEGIC PATHWAY 2 Legal and Policy	Establishes a robust legal and policy framework that is essential to institute appropriate national geospatial information legislation and policy that enables the availability, accessibility, exchange, application and management of geospatial information. The objective is to address current legal and policy issues by improving the laws and policies associated with, and having an impact on, geospatial information management; and by proactively monitoring the legal and policy environment, particularly with regard to designating the official responsibility for the production of data, and with respect to the issues raised by emerging technologies and the evolving innovative and creative use of geospatial information.
STRATEGIC PATHWAY 3 Financial	Establishes the business models, develops financial partnerships, and identifies the investment needs and funding sources for delivering integrated geospatial information management, as well as recognizing the benefits realization milestones that will achieve and maintain momentum. The objective is to achieve an understanding of the implementation costs and ongoing financial commitment necessary to deliver integrated geospatial information management that can be sustained and maintained in the longer term. Investment in all strategic pathways is paramount.

STRATEGIC PATHWAY 4 Data	Establishes a geospatial data framework and custodianship guidelines for best practice collection and management of integrated geospatial information (accurate, logical, consistent, standardized and interoperable) that is appropriate to cross sector and multidisciplinary collaboration. The objective is to enable data custodians to meet their data management, sharing and reuse obligations to government and the user community, through the execution of well-defined data supply chains for organizing, planning, acquiring, integrating, managing, maintaining, curating, publishing and archiving geospatial information.
STRATEGIC PATHWAY 5 Standards	Establishes, and ensures the adoption of, best practice standards and compliance mechanisms that enable legal, data, semantic and technical interoperability, which are fundamental to delivering integrated geospatial information and knowledge creation. The objective is to enable different information systems to communicate and exchange data, enable knowledge discovery and inferencing between systems using unambiguous meaning, and provide users with lawful access to and reuse of geospatial information.
STRATEGIC PATHWAY 6 Innovation	Recognizes that technology and processes are continuously evolving; creating enhanced opportunities for innovation and creativity that enable governments to quickly bridge the digital divide. The objective is to stimulate the use of the latest cost-effective technologies, process improvements and innovations so that governments, no matter what their current situation, may leapfrog to state-of-the-art geospatial information management systems and practices. Acknowledges that government agencies are not normally the first to implement novel and new solutions, and that industry is often leading innovation.

STRATEGIC PATHWAY 7 Partnerships	Establishes effective cross-sector and interdisciplinary cooperation, industry and private sector partnerships, and international cooperation 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 trusted partnerships and strategic alliances that recognize common needs and aspirations, and national priorities.
STRATEGIC PATHWAY 8 Capacity and Education	Establishes enduring capacity-building programs and education systems so that geospatial information management and entrepreneurship can be sustained in the longer term. The objective is to increase the awareness and level of understanding of geospatial information science. This includes developing and strengthening the skills, instincts, abilities, processes and resources that organizations and communities require to utilize geospatial information for decision-making. Recognizes that the human resource asset is the most critical – the people.
STRATEGIC PATHWAY 9 Communication and Engagement	Recognizes that stakeholders (including the general community) are integral to the implementation of integrated geospatial information management systems, and that their buy-in and commitment is critical to success. The objective is to deliver effective and efficient communication and engagement processes to encourage greater input from stakeholders to achieve transparent decision-making processes when implementing the Strategic Framework.

2.12 Benefits

Broad societal benefits that include the citizen, community and country, in the three areas of sustainable development – social, economic and environmental, and leveraging the value of data, technology and innovation to derive outcomes that include decisions, knowledge, development – and ag the end of the day, national prosperity and deliver the vision and mission of the Strategic Framework.

2.13 Implementing the National Strategic Geospatial Information Policy Framework

Noting the 2030 Agenda's promise to leave no one behind, and the commensurate expectations that by 2020 countries will need to have increased significantly the availability of high-quality, timely and reliable disaggregated data, this Strategic Framework has been developed in a rapidly changing environment. Despite the many challenges in developing countries, community expectations are evolving with advancements in technology and the gradual increase in computer literacy. Governments are recognizing that to maintain relevance with the prevailing societal needs and ambitions there is a need to deliver geospatial information in a way that can be visualized and used anywhere, anytime and on any electronic device. Staying abreast of community expectations and having a sense of where the best public value is now and in the future, remains a key responsibility of Government.

This Strategic Framework has responded to these community aspirations and the urgent need for its implementation, and now underpins the United Nations Integrated Geospatial Information Framework (IGIF), adopted by UN-GGIM at its eighth session in August 2018 [31]. Based on the Strategic Framework, the IGIF was developed in 2018 as a collaboration between the United Nations and the World Bank to provide a basis and guide for lower to middle income countries to reference when developing and strengthening their national and sub-national arrangements in geospatial information management and related infrastructures. Prior to its adoption, the IGIF was submitted to all Member States for global consultation, which sought inputs regarding the overall structure and substance, if the approaches and levels of detail were suitable, and if the structure was a reasonable approach to deliver the IGIF to the global community.

The IGIF is seen as being comprehensive and provides a clear vision and mission on how to develop and facilitate the utilization of geospatial information at the national level. For developing countries, it is a valuable tool to be utilized to bridge the geospatial digital divide. Despite its comprehensiveness, the IGIF is still clear enough to be used at the highest level. It was considered valuable to identify the seven underpinning principles, eight goals and nine strategic pathways; several countries even expressed interest to expand these further. Importantly, the IGIF was strongly supported by African countries, whom had the opportunity to provide inputs into an early version in April 2018. This proved a valuable exercise, as the African countries were able to voice their concerns towards ensuring that the IGIF is organized in such a way that it could be readily used as a guidance to establish a geospatial information management system in their countries. They also reiterated the importance of international cooperation, 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 spread the importance of geospatial information across national aspects. It was noted that international cooperation donors require a strong business case and confidence in governance before releasing funds to countries, and that the IGIF provides that confidence.

Member States have emphasized 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.

2.14 Conclusions

Framed by the 2030 Agenda for Sustainable Development, this chapter presented and discussed the major components to assist continued efforts in charting a geospatial roadmap towards the implementation of the SDGs. It first contextualized sustainable development broadly, and its evolution towards the 2030 Agenda, before visiting the goals, targets and global indicator framework in detail. The chapter then described 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 concluded 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.

In recognition of its value and urgent need, the Strategic Framework has been used as the basis for the overarching strategic framework for the Integrated Geospatial Information Framework, adopted at the global level by all countries of the United Nations as a means to assist countries in developing and strengthening their national and sub-national arrangements in geospatial information management and related infrastructures – to bridge the geospatial digital divide and to leave no one behind. Many countries are now looking at implementing the Framework with guidance by UN-GGIM and the World Bank, whom are now collectively developing a detailed Implementation Guide and Country-level Action Plans.

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3

Marriage of Opposites: Strategies for Public and Private Sectors Working Together in Land Tenure Reform Projects That Support SDGs

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In the context of land tenure and SDGs, this chapter proposes strategies for practitioners to involve the private sector in land administration services while at the same time ensuring there is a contribution to the achievement of the SDGs.

3.1 Introduction

SDGs provide a framework for governments, multilateral organisations and donors to drive social investment on sustainable development. Among the 17 SDGs, SDG1(No poverty) SDG2 (Zero hunger) and SDG5 (Gender equality) directly highlight the importance of land tenure systems as a mechanism to achieve sustainable development. These goals focus on encouraging investment in land tenure security (LTS) around socially vulnerable groups (particularly the poor), land productivity and gender imbalances.

For over 20 years governments in developing countries, with the support of organisations such as the World Bank, have invested worldwide on improving the certainty of rights, restrictions and responsibilities by implementing land tenure reform projects. Traditionally efforts have focused primarily on the land right registry and cadastre systems and - more recently - spatial planning and natural resources systems. Most of the investment has focused on large scale systematic registration activities aimed at improving coverage, building

information technology (IT) systems, reviewing and reforming institutions, technical capacity building and improving the regulatory framework.

There is an increasing trend across most developed and developing countries to involve the private sector in the delivery of land cadastre and registration services. This trend follows significant results in the infrastructure sector (in areas such as ports, roads and hospitals) where many countries have leveraged new investment by making the private sector and active partner that takes risks, invest resources and achieve social results.

Considering this current landscape for land reform projects, strategies proposed in this chapter are: (i) to target areas where the private sector can do a better job; (ii) find cross-services approaches within the land administration system (iii) build the participation in a trusted private sector; (iv) revenue should be based on achieving tangible social results aligned with SDGs.

Strategies presented in this chapter are proposed to be used during the design and implementation of future land reform projects both in developed and developing countries. Some areas for further research including better mechanisms to strengthening gender equity and synergies between these proposed strategies and others focused on productivity.

3.2 Background: Land Administration and the Trend of Involving the Private Sector

Land administration in this chapter relates to the institutional systems (at a national or sub-national level) that regulate all activities that require the use of land. The core of a land administration system is the cadastre or inventory and description of all parcels in a jurisdiction. Most modern cadastre systems in developed countries have a digital geographic description of the parcels, and they cover the entire area of the country [42].

Depending on the system, the cadastre is contained or be linked to a land registry in where rights, restrictions and regulations are typically stored. In this, tenure rights are fundamental as they underpin the ability of a person or group to conduct economic activities and participate actively in a land market by buying, renting or selling land properties.

In addition to the cadastre and the land registry, land administration systems cover many other areas of a nation or region such as land taxation systems; development and building permits; mining rights; and water concession registries.

Considering the importance of land administration systems for all nations, and particularly a cadastre system with an appropriate land registry, many investment projects have been conducted to improve it. Commonly in the literature, these projects are described as land tenure reform projects as they focus on enhancing government systems related to land rights.

This chapter explores the evolution of these land reform projects and the new trend of involving the private sector as a critical participant in the developing and funding of these projects and more broadly the land administration system. In particular, the focus is on analysing experiences in where public-private partnerships (PPPs) or similar instruments have been used in land reform projects and draws. Lessons are drawn from selected cases studies to develop strategies for ensuring private sector participation in land projects support the implementation of sustainable development goals (SDGs). These strategies, which are the main contribution of this chapter, are applicable in both developed and developing countries and are proposed to be considered during the design of future projects where it is desired to transfer significant responsibilities to the private sector. Ideally, these strategies will support developed and developing countries when reviewing future land reform projects or considering unsolicited proposals submitted by the private sector. Additionally, proposed strategies for private sector involvement in LTS provide assessment parameters for donors and multilateral banks to understand better the contribution of the private sector in a land reform project.

The rest of this chapter is structured as follows: The next section presents an analysis of SDGs and its relation to LTS. Section 3.4 presents the current opportunities and challenges of land reform projects. After this, a critical review of a selected number of case studies where the private sector plays a significant role in the delivery of LTS is presented in Section 3.5 . Section 3.6 gives the main contribution of this chapter which are strategies for PPPs and other mechanisms for involving the private sector in land reform projects in a way that is aligned with SDGs. The chapter finalises with conclusions and general suggestions for further research and development in Section 3.7.

3.3 SDGs and Land Tenure Reform Projects

For over 25 years and since the first Earth Summit, organised by the United Nations (UN) in 1992 in Rio de Janeiro (Brazil), there has been a collective effort to promote a set of goals for all nations, particularly those experiencing poverty and social challenges. In 2016, SDGs replaced the Millennium Development Goals [26].

Although reviews are mixed on the level of achievement obtained by the world in relation to the MDGs [11, 13] there are significant benefits for nations, their development agencies, international donors and multi-lateral banks on having agreed and targeted common goals [4, 27]. Among others, the adoption of SDGs by over 170 nations:

- encourages coordination among different actors involved at the national and international development

TABLE 3.1
SDGs target and indicators directly related to LTS. Data from [19]

Goal	Target	Indicator	Relation to LTS
SDG1: No poverty	1.4	1.4.2	Indicator 1.4.2 directly mentions secure tenure rights in adults and vulnerable groups as a key element to achieve SDG1. This indicator covers both urban and rural land
SDG2: Zero hunger	2.3	n/a	Target 2.3 has a direct mentioned to equal access to land, a concept directly related to LTS. However, no indicator is proposed for measuring this access
SDG5: Gender Equality	5.a	5.a.1	This target and corresponding indicator tracks the participation of women in land ownership, measured based on the LTS
		5.a.2	This indicator assesses the legal framework of countries to determine the level of equality related to land for women

- facilitates the development of indicators and targets
- promotes standards for social responsibility actions by the private sector

SDGs are 17 goals that cover most of all human and natural activities on earth. In previous chapters of this book, many SDGs have been explored, particularly those related to land planning, geographic information systems and land productivity. This chapter will focus on SDGs that are directly related to land administration, mainly those goals where land tenure security improvements play a role in achieving it. Table 3.1 presents a summary of SDGs identified to have a direct relationship with LTS. The author acknowledges that other SDGs have an indirect relationship with LTS. This is the case of SDG11 and SDG15 where the use of land as a critical development resource is promoted. However, and considering the desired focus of this chapter of the practical application of results on land reform projects, only those goals, targets and indicators in where land tenure is directly mentioned and measured has been included in this analysis.

The development of the SDGs and its monitoring and reporting has not been free of controversy. This was the case for land tenure related indicators in where norm contestation, evolution and change occurred during the international consultation process conducted by the UN [36].

Additionally, Agarwal (2018) has questioned the efficacy of SDG5 to empower women as the emphasis of the indicator on LTS needs of women did not consider the other relevant economic factors for making lands productive such as access to credits and irrigation schemes [1]. Therefore, in many cases,

improvement of LTS for women (SDG5) and other vulnerable groups (SDG1) would need land reform and also other development projects, such as agricultural productivity, employment and better access to financial instruments.

In some cases, practitioners designing land reform projects in line with SDGs would have to expand beyond the three core LTS goals identified in this section as LTS plays a role in many nexus underpinning achieving the SDGs [41].

In summary, SDGs has provided an overarching objective to LTS to ensure land rights are correctly documented and protected by governments in a universal way. Additionally, and to contribute to SDGs, LTS implemented using land reform projects should address gender land gaps, which is a significant problem today [12]. In practical terms, SDGs dictates that gender equality is achieved in numbers (number of women owning land) and land regulatory frameworks that abolish discrimination.

3.4 Land Reform Projects: Achievements and Challenges

Proper land administration, where the cadastre and land registration information systems underpin significant activities related to land, is vital for sustainable development [42]. Without proper land management, policies and actions needed to address emerging challenges are jeopardized. In a well-developed land administration system, decisions by government bodies related to sustainability, such as the use of natural resources, construction and the implementation of environmental policies, are underpinned by information in national spatial data infrastructure (NSDI) capable of allowing information sharing and cross-referencing using coordinates [34].

The importance of investing in better land information systems in developing countries gained strength in the late 80s and 90s as countries realised proper land administration enables better investment by the public and private sectors while creating a platform for disadvantaged social groups, particularly the poor, to participate actively in market economies [31]. Land reform projects, directly related to improving LTS, have been the prime instrument for advancing land administration systems.

Today, there are significant opportunities for land reform projects including new technologies - such as drones and portable devices - for the collection of geographic information [24, 32]. There is also the digitalisation of data and operations of many government functions including those related to land administration [18]. Automation has also offered as an alternative to improve transaction times while reducing corruption and costs [40].

However, there are challenges today for the government, donors, multilateral organisations and other designing and funding land projects. Primarily,

there have been mixed results on the effectiveness of the investment [15] and the borrowing capacity of countries along with their ability to generate public funds has created a strong tendency to involve more actively the private sector as a financial partner of land reform projects. This trend is well expressed by the recent policy "maximising funding for development" from the World Bank [2] and follows the same pattern that has occurred already in other sectors - particularly infrastructure development sector such as port and roads - in where funding projects using public-private partnerships is common [28].

Additionally, there is an increased focus of land reform projects on urban areas due to the urbanisation pattern occurring in most countries in the world [35]. This brings new challenges to practitioners as areas with high population density generates additional social problems [43].

The focus on urbanisation is also an opportunity for future land reform project. Urban land reform projects are likely to be conducted in more economically active areas or where a land market is more feasible compared to rural zones. This allows increased possibilities for land administration system users to pay for the services, a situation that creates possible synergies between urban land reform and private participation in running the system under PPPs.

Multiple studies have reviewed approaches conducted by the World Bank and other multilateral organisations for land reform projects [22, 5, 10, 33]. However, after over 30 years of investment in developing countries land administration systems, it is difficult to identify approaches that are likely to work in all context.

In any case, there are some general views in the international community of crucial principles most land reform projects should follow to be successful and contribute to sustainable development.

Acknowledging this space is always changing; the following list presents some principles today for land reform projects that are considered to be in line with the private participation focus of this chapter:

- Fit-for-purpose: improve land tenure rights by fostering innovation in approaches and new technologies in land administration with the objective of optimising resources by investing in the collection and processing of land information in a way that best fits the specific conditions [9].

- Data and process standardisation: standardisation of data topology and processes within a particular jurisdiction to improve information sharing, optimising resources and reduce errors and duplication [20].

- Community mapping and crowdsourcing methodologies: the use of technologies and methods, particularly portable devices and open public participation, to collect information with the community as an active participating party with roles and responsibilities [6].

- Responsible private sector participation: ensuring the private sector (both

involved in the provision of land administration services and in the land market) have partnership participation in land reform projects that find common goals with public policies [22].

In summary, land reform projects are a fundamental investment for governments to achieve sustainable development. New technologies, automation and digitalisation of government services is facilitating the construction of better land administration systems. However, the government has limited resources and borrowing capacities to invest in this project are decreasing. The new trend in the land registration and cadastre sector, as it has happened extensively with infrastructure projects, is to generate new funds for land reform projects using PPPs. Although it is difficult to generalise, there are some high-level principles learnt from over 20 years of land reform projects that are important for considering the participation of the private sector in the implementation. These principles are fit for purpose; data and process standardisation; community mapping and responsible private sector participation.

The next chapter reviews land reform projects that have included a significant component of private sector participation and provides a summary of lessons learnt from these experiences.

3.5 Lessons Learnt From Involving the Private Sector in LTS

The private sector could be included in land reform projects in multiple ways. The World Bank and other international institutions. Grave (2015) explained this participation along with a definition of PPPs [14].

This section presents 5 case studies (Switzerland, Canada and Australia in developed countries and the Philippines and India in developing countries) from where proposed strategies where drawn. The presentation of the case studies focuses more on the lessons learnt applicable to future project design. The author acknowledges that these 5 cases studies do not cover all experiences relevant to LTS and the private sector. Other literature has coated more extensive those international experiences of land reform projects with a significant private sector component [39].

3.5.1 Switzerland

For many years, the Swiss cadastre has been recognised as probably one of the most developed systems in the world. However, only now that there is a trend to involve more the private sector in land administration systems, practitioners have started to recognise that one of the main characteristics

of the Swiss cadastre is that for many years it has had significant participation of private surveyors. Switzerland is a small country - both in size and population - compared to international standards. However, it has a complex, decentralised government system with 26 cantons (call states or departments in other jurisdictions) and almost 2600 municipalities in a country with four official languages [38].

This complex environment for the land administration systems required the development of methods and protocols that allowed proper communication between entities at all levels while providing an effective and efficient service to users.

To address this complex environment, the federal government developed a scandalised data model and exchange format for geographic information called Interlis. Initial development of the system started back in 1987, and a consolidated operational version for the cadastre began in operation in 1993 with its adoption by the Federal Government [37].

Today, based on Interlis, the Swiss cadastre has two models of private participation in the creation, running and development of the cadastre system. This participation is based on a strict certification process to surveyors, and the delegation is given to individuals. Based on [3], the models of private involvement in the cadastre system are:

- Delegation: On the German part of the country, an exclusivity arrangement for five years is agreed with a surveyor selected using a tender process. The private surveyor has fixed prices for all official land measurement jobs, and she/he is responsible for hosting and transmitting information.

- Competitive market: On French areas, there is an open market and individuals or companies requiring modifications to the cadastre can contract any surveyor on an open market. However, surveyors generally based their prices on a standard list called HO 33. In these areas the maintain of the cadastre could be done directly by the cantons or delegated to individual surveyors based on a competitive tender

The current scheme of data sharing and participation of the private sector in the Swiss cadastre has contributed significantly to Switzerland economic productivity, stability and well-developed land market [17]. Key lessons, perhaps adjustable to other cases, from the Swiss experiences with the private sector in land administration are:

- *The importance of Interoperability:* Interlis, the legally bounding data topology and format for geographic information, has been the enabling force to allow delegating multiple sections of the cadastre system to the private sector, mainly being the data custodian. Additionally, it enabled participation of the private surveyors at different levels and modified based on the needs of the cantons and municipalities

- *The creation of a trusted private sector:* Federal regulation demand strict education and examination of those intending to become private surveyors in Switzerland. This has created the ability of the government to trust surveyors with complex functions and participate actively in the land administration system

3.5.2 Canada

The literature on the privatisation of the land registration in the provinces of Ontario and Manitoba is extensive [30] as these case has been identified as a critical landmark in the privatisation of land registry services. The case of Ontario is analysed next.

In the 80s, the province of Ontario decided to privatised its land registry services with the objective of providing a better service and reducing running cost as the paper-based system in place could not coup properly with an increased demand in land transactions. The slow progress on government reform, something that has been a constant driver for many land system privatisations, created the appropriate political environment for a change for a PPP of the land registry system.

Based on an open request for proposals, the government offered 50% of the ownership of the land registry for an initial period of 15years. The province signed a contract with the preferred bidder that initially was a lease contract and evolved into a concession. The new entity, called Teranet, had the primary task of delivering significant modernisation of the system including the digitalisation of records and ability to process request online. Later in the process, the public share of the concession was sold, and the operation became 100% own by the private sector.

The primary financial arrangement of the concession was based on a "users pay approach" with a clear return for the private investor and revenue collection for the government. In 2010, after a significant financial and technical success of the first concession, Teranet paid $1 billion for continuing the concession for an additional 50 years.

Key lessons learnt from privatisations of the land registry in Canada, which has been in operation for more than 30 years, are:

- The government managed to generate interest in the private sector in what was an unknown territory by offering to share risk from the beginning of the project. This created the possibilities during the first five years of stabilisation of the project, including reforming the law and adjusting the financial scheme to generate value for money to the government and profit opportunities for the private sector

- An explicit policy of the data ownership allowed for innovation by the private operator while maintaining certainty to the government. In Ontario,

Teranet has been able to develop additional income sources by using the land registry data beyond the traditional scope of LTS.

3.5.3 Australia

Australia is one of the most recent examples of privatisations of land registry. The government of New South Wales (NSW), Victoria and South Australia have completed PPPs of their land registries and are in their initial operation phases. The state of Western Australia is also in the process of completing its concession.

The main characteristic of PPPs in Australia is the focus of the government on selling an asset in the same way back in the 80s and 90s when across the developed world public infrastructure assets (such as ports, public transport and roads) where concession to private operators.

The process has been very similar in all jurisdictions in Australia. An initial scoping study is followed by a legal reform that then enables a tendering process where the asset is sold primarily to the higher bidder.

Even though the process has resulted in financial results that exceeded initial government estimates, the concession in Australia has not been free of controversy. Notably, there have been questioning from professional associations on the financial return focus, and the fact that the resources received have not been invested back on LTS.

In any case, there are significant lessons learnt in Australia that could be used in other jurisdictions. These are:

- The private operator is assuming substantial financial risk as its revenue depends on fees paid by those conducting transactions in the land market. This is expected to create the appropriate incentive to reduce costs and foster innovation, including automation of some transactions which has been proposed for the NSW operator and it is supposed to be included in the other two concessions

- Even though significant risks have been delegated to the private sector, the underpinning principle of a state guarantee for land transactions remains intact. In other words, in Australia today the ultimate responsibility for guaranteeing land transactions still is the government, creating that a vital principle of the torrent system is not being modified.

3.5.4 Philippines

Back in 2007, the land titling computerisation project (LTCP) was implemented in the Philippines [21]. This project was underpinned by two consecutively large-scale systematic registration projects conducted in the country

since 2001 [16]. LTCP has as objectives tackle high land registration costs, corruption, slow government reform and low level of taxation. LTCP was built under a PPP model of a build-Own-Operate model. To partly fund this concession, the international finance corporation (IFC) participated in the initial financial arrangement.

Eleazar et al. (2013) evaluated the results of this concession and highlighted some of the problems including high transaction costs that limit the ability of the community, particularly the poor, to access the land titling service [7]. In any case, there significant lessons that could be learnt from what is described as the first land registration PPP in a developing country:

- LTCP run in parallel with the second phase of the land titling project funded by the World Bank. This allowed the concessionaire to explore synergies from the public investment in LTS and, at the same time, generated a sense of sustainability of land reform projects, something fundamental for the country
- The design of the concession highlighted the need to define clear public objectives for a concession beside economic efficiencies and other public sector problems such as corruption. In particular, the Philippines LTCP project is an essential example of challenges to vulnerable groups when market-driven approach as implemented in land administration services

3.5.5 India

The case of Karnataka province in India demonstrates the application of PPP approaches to multiple land administration services at the same time. The project, called Bhoomi, was initially conceived as a pilot project and later evolved as a PPP. In this project three land administration services are a concession to a private operator [25]:

- Digitalisation of records, both new and existing
- Registration of crops so loans and other government services can be provided
- Online transactions

An important objective of the project was to reduce corruption as both LTS and crop registry generated significant economic activity in the region. The digitalisation approach aimed at simplifying the process and securing the data while improving data accessibility and building a robust database that allows cross-referencing with other data sources. Although the results are mixed [25] Bhoomi project is considered a significant experience for the participation of the private sector in LTS and other government functions. Key lessons, relevant to the focus of this chapter, include:

- The success of the Bhoomi project was attributed in many cases to the combination of LTS and crop registry services. These two services needed each other to exist as LTS define the land rights for agricultural activities and the crop registry a market motivation and financial resources for users to request LTS in their land
- There has been a significant in corruption from the project demonstrating that not only financial benefits but the protection of land rights to the most vulnerable, could be achieved using the appropriate mechanism to involve the private sector

3.6 Strategies to Align Private Participation in Land Tenure Reform Projects With SDGs

Although there is significant literature exploring the involvement of the private sector in LTS projects [25], there is limited academic or professional material analysing this private participation and its contribution to SDGs. Meadows, Fairlie et al. (2018) developed an analysis or pre-requisite for the development of PPPs in the land administration sector and Endo, Triveno et al. (2018)analysed the new roles the private sector is playing in land reform projects based on experiences in Latin-American [23, 8].

Based on [29] conceptual design for assessing the viability of PPPs in the land sector, a multi-criteria analysis was conducted to identify areas where strategies were developed. The following table 3.2 shows this multi-criteria analysis. In this table, the first column presents the identified characteristics required for a land PPP to be viable. The second column identifies the relationship with one of the LTS related SDGs discussed previously in this chapter. Finally, a relationship with lessons learnt from previous experience, explore in the previous sections, is included in the last column.

Based on the multi-criteria, gaps on needed strategies were identified, particularly the fact that gender equality has not been correctly addressing as a key condition for PPP viability. Based on these gaps and using the analyses from the previous sections, the following strategies are proposed for designers and implementers of projects where the involvement of the private sector is expected to be significant.

Strategy 1: Involve the private sector in the area where it can best perform

Based on the cases in Switzerland and Australia in where the private participation is segmented to where it best suits the local and national needs, land reform project designers should consider involving the private sector only in segments or areas where it can better help the government in achieving SDGs.

TABLE 3.2
Multi-criteria analysis to identify

Viability condition for a land PPP [29]	**Related SDGs**	**Related case study lesson learnt (previous section)**
State or another guarantee to transactions	SDG2	Australia
Clear definition of properties	SDG1, SDG2	Multiple
Legal delegation to the private sector	SDG2	Australia
The existence of a regulatory authority	SDG2	Australia
Avenues to resolve disputes	SDG1, SDG2	Canada
Process fees and responsibilities for all transactions are well defined	SDG2	India
The regulatory framework considers fit-for-purpose	SDG2	India
Secured and accessible land records and information about the land system	SDG1, SDG2	Switzerland
Mechanisms to handle complains	SDG2	India
Revenue from transactions is clear	SDG2	Philippines, India
There is a strong private sector operating PPPs in other sectors	SDG2	Philippines, Australia, Canada
Risks and reward for the private investor can be clearly defined	SDG1, SDG2	Switzerland
Funds are available to structure a land PPP	SDG1, SDG2	Australia

These areas of segmentation could be either geographical or institutional. In Switzerland, the roles of surveyors vary depending on the canton while in Australia (both in NSW and Victoria) the privatisation occurred on the land registry and not the cadastre.

When doing this segmentation, project designers could better identify if which of the LTS related SDGs could be better addressed. In many cases, there are opportunities to build packages of providing highly profitable areas with those that might not raise revenue but could table better gender equality (SDG5) and title for the poor (SDG1).

Strategy 2: Cross-service approaches

One of the most significant advantages of the Karnataka in India is the delegation of multiple land administration services into one PPP. Designing cross-service approaches in land PPP and other projects could better allow supporting the achievement of SDGs. In particular, joining the land tax collection service with land registry and cadastre services opens the opportunity for the private operator to invest in low-income areas (SDG1) with the prospectus of generating wealth in the long term and improve tax collection. Similarly, like in Karnataka, titling activities could be directly related to other fees such as crop registration, building and development permits and forest licenses, creating additional sources of income to expand LTS.

Strategy 3: Work with the trusted part of the private sector

Success in Switzerland of its delegation of cadastre services to the private sector is underpinned by the trust that exists on the surveyor's registration system. Similarly, privatisations in Australia are considering very successful from a financial point of view because the government has created mechanisms to trust private investment banks and pension funds as owners of land administration services. Both developed countries are currently achieving this trust in the private sector SDG1 and SDG2.

Therefore, as a mechanism to foster achieving SDG1 and SDG2, project designer should consider delegating the land administration services on those segments of the private sector that are well trusted by society. In some cases, it might be the financial sector, the insurance sector, certain professions (lawyers, surveyors) or private associations (such as the chambers of commerce).

Strategy 4: Result-based revenue

A key opportunity politicians have is to define the objective of a project they are willing to support which in most cases should be aligned to the SDGs. Therefore, project designers should ensure that revenue received by the private sector is achieved when these objectives are met. The case in the Philippine demonstrates a situation where this strategy was not used and cause the opposite effect: revenue conditions limit achieving better LTS.

Result-based revenue would be a particularly useful strategy for projects

focusing on SDG5 as gender equality is difficult to encourage to a private operator. However, for example, extra revenue could be negotiated with a private operator of a land system to those titling registration that includes women, encouraging this private operator to invest and prioritize equal land ownership in the areas covered by the project.

Other sectors, including water and education, have used this approach (Fritsche, Soeters et al. 2014)and is also referenced in the literature as results-based financing.

3.7 Conclusions

It is not hard to find agreement between researchers and practitioners in need for more investment in land reform project as a mechanism to foster the achievement of SDGs. Although SDGs could be seen as generic and covering all aspects of a nation, there are 3 SDGs (SDG1, SDG2 and SDG5) that directly address the need for better land administration services.

Land reform projects are facing both challenges and opportunities. To address the problem of financial resources and to build from the innovation opportunities, there is a current trend that suggests the involvement of the private sector could potentially foster the development of land reform projects.

Examples around the world where the private sector plays a significant role in running land administration systems have provided valuable lessons. Notably, all future projects need for government to have the right financial, administrative, legal and regulatory framework in place to ensure private participation under a partnership arrangement and not just transfer the problem.

Four strategies are proposed for practitioners and government officials involved in the design and implementation of land reform projects with significant private sector participation:

- Involve the private sector in the segment or geographic areas where it can best the SDGs
- Bundle land administration services with LTS to ensure there are more opportunities to invest in land rights
- Work with the trusted segment of the private sector
- Private sector revenue should be linked to the SDGs that are being addressed

Even though it is challenging to make the sector a decisive contributing factor of the SDGs for the provision of land administration services, there are lessons learnt and strategies that could make this happen. However, the four strategies presented in this chapter address timidly SDG5 (tender equality)

as there are limited experiences, particularly in the developing world, where the private sector participation has contributed to women rights. The need to develop strategies to better involve the private sector in gender equality is suggested as an area for further research.

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4

Spatially Enabling the SDGs: The Social, Economic, and Environmental Impacts of Spatial Enablement

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This chapter aims to present the significance of spatially enabling the SDGs and the opportunities it provides for the seventeen goals.

4.1 Introduction

Achieving the Sustainable Development Goals (SDGs) is contingent on a holistic approach that aligns social, economic, and environmental objectives at local, national, and global levels. The significance of the 'where' component of the SDGs is, however, often underemphasized. The Global Goals require a transdisciplinary effort to integrate the geospatial aspect into planning and implementation phases, and UNHCR and ESRI's collaborative initiative, *Rohingya Refugee Emergency at a Glance* is a case in point that utilizes geospatial information and technologies to address various dimensions of sustainable development in parallel with changing circumstances. The interactive platform locates health services, disaster risks, shelter congestion, and water accessibility to sustainably aid Rohingya refugees in Bangladesh [29]. This example demonstrates how integrating spatial enablement in SDGs-related initiatives can create resilient and sustainable circumstances for everyone in every location.

The SDGs have emerged in a world where social, economic, and environmental complexities are intertwined across different geographic locations and at a time when technological advancements encourage the proliferation of real-time and location-based information. Spatially enabled societies, governments,

and people can offer a wide range of solutions for complex challenges [23], however how it connects the multidimensional SDGs and its social implications for a comprehensive approach requires further research. The chapter begins by examining the meaning of spatial enablement in the context of the SDGs and is followed by a discussion on how spatial enablement can narrow the SDG connectivity gap. It then 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.

4.2 Spatially Enabling the SDGs

4.2.1 What Does It Mean to Be Spatially Enabled?

Social, economic, and environmental developments are geospatial processes, because "everything happens somewhere"[1]. Moreover, location is "the fourth element of decision-making" [23], therefore recognizing and utilizing geospatial information to localize solutions is essential to progress. This geospatial need prompted the emergence of 'spatial enablement', a notion to facilitate localization by cohesively engaging technologies, people, and institutions. In broad terms, to be spatially enabled is the ability to use geospatial information and technology to enhance the interactions within that space [8]. In technical terms, spatial enablement refers to geographical identifiers–e.g. geographically tagging records in a database [7]. The term generally entails the use of geospatial information and technologies to ameliorate the social conditions. However, geospatial experts emphasize that spatial enablement is not merely a technical matter, it is an approach that is concerned with the whole of government and society [32]. To this end, spatial information and technologies serve to spatially enable two main entities: society and government.

A spatially enabled government works towards establishing infrastructures that organize and share spatial information required for decision-making and policies, government services, business transactions and community activities [33]. Integrating spatial data infrastructures (SDIs) and better land administration and management (i.e. land governance, property rights, and land policy) allows governments to utilize spatial information to address social, economic, and environmental challenges adequately [30]. In essence, a spatially enabled government is a facilitator for interactions between organizations, technologies, and people by means of a common language using spatial concepts and technologies, and spatial information management processes

[1]This statement is credited to Nancy Tosta in an interview with the Computer World news, GIS: More Than Just A Map. Retrieved from https://www.computerworld.com/article/2582595/gis–more-than-just-a-map.html

[7, 9]. Therefore, spatially enabled governments utilize geospatial knowledge and technologies across different domains and sectors to fulfill societal needs.

Similarly, a society is spatially enabled when spatial information, a common good that prompts creativity, efficiency and product development, is available to governments, citizens and businesses to organize and plan their activities [18, 33]. The International federation of Surveyors (FIG) report, *Spatially Enabled Society* [23], defined the term in the context of availability, accessibility, and usability of spatial information. First, spatial information and services must be available to governments, businesses, and citizens in a free, efficient, and comprehensive manner. Second, tools for spatial information sharing, analysis, and management must be accessible to all sectors of society. Third, spatial information must be used to transparently organize economic, legal, environmental, land, and social activities, and contribute to informed decision-making. The ultimate objective of is to provide value-added services and reinforce sustainable development through six fundamental elements: legal frameworks, sound data integration concepts, positioning infrastructures, SDIs, land ownership information, and data and information.

Spatially enabled societies encourage the collection and processing of spatial information at all levels of society to deliver sustainable development objectives [31]. Land administration systems and SDIs use the collected data to underpin evidence-based decision-making to implement sustainable policies and practices [4, 17]. Therefore, the integration of spatial information and technology in sustainable development can facilitate coherent governance, ensures coverage of more geographic territories, and engaging a larger number of citizens in determining the future of their society. While geospatial information offers of social, economic, and environmental benefits, most countries lack the capacity to manage and share geospatial information and systems to advance sustainable development goals [6]. In spite of limitations in geospatial resources and skills, the SDGs generated a new wave of geospatial awareness at a global level.

4.2.2 Sustainable Development Goals in an Interconnected World

In recent decades, the global community has become interconnected across different geographies, scales, and sectors, driving us into the age of sustainable development [19]. The universality and complexity of our challenges brought together the largest international gathering at the UN Conference on Sustainable Development (Rio+20) in 2012. The Rio+20 outcome document declared that sustainable development goals should be action-oriented, consider different national realities and capacities, and utilize geospatial information for policymaking, programming, and project operations [10]. As a result, the SDGs were put into effect in 2015 to mobilize a transformative course of action towards a sustainable future for people and the planet. The 2030 Agenda

requires data-driven action, evidence-based analysis, implementation, monitoring [20] and capacity building that is linked across different sectors [22].

Geospatial analysis, mapping, and modeling, geopolitical policy, and integrative frameworks can fortify networks of capacity building and decision-making practices needed for sustainable development issues [25]. In other words, spatial enablement offers the knowledge and tools needed to spatially connect stakeholders, policy makers, and people to sustainability challenges, resources, and solutions. Thus, integrating geospatial information in the global agenda promotes a holistic approach to measuring and monitoring the SDGs. The collective success of the global community depends on a holistic framework and transdisciplinary action plan that spatially enables the SDGs to deliver social well-being, economic growth, environmental vitality, and good governance.

4.2.3 Integrating Spatial Enablement Into the SDG Framework

The 2030 Agenda is one of the first global frameworks that recognizes the role of geospatial information in sustainable development [21]. The 2016 SDGs Report noted that geospatial information is important for the production of some indicators [12] and falls short of providing any details. The 2017 SDG Report reiterated the same statement without providing further information [13]. Progress was made in the 2018 SDG Report, it called for open and transparent access to integrated geospatial and statistical data, collaboration on the production and dissemination of geospatial and statistical data, and visualizing SDG statistical data within a geospatial context [14]. While the importance of geospatial information is recognized in the framework, there are missing links between spatial enablement and the SDGs.

The Inter-agency and Expert Group on Sustainable Development Goal Indicators (IAEG-SDGs) Working Group on Geospatial Information has examined the SDGs with a "geographic location lens" and proposed that geospatial information has direct contribution to fifteen indicators and supporting contribution to eight indicators [27]. The list of indicators does not, however, encompass all indicators that are geospatially relevant. Target 3.3, for example, intends to end the epidemics of communicable diseases, and geospatial data is necessary for tracking and analyzing disease outbreaks [1]. This indicates that the role of spatial enablement in social, economic, and environmental phenomena has not been comprehensively researched. Therefore, this chapter proposes spatial enablement creates three key opportunities for the SDGs:

Inclusive coverage of SDGs. 'Leaving no one behind' is the key pillar of the SDGs, which requires the integration of where people are and where events occur with demographic data in order to provide geospatial services that are accessible and consistent [24]. Twenty-one of the SDG targets intend to increase access to basic services, land, housing, and other resources, all of

which, require spatial data (remote sensing data, satellite data, etc.) to ensure that 'accessibility' is for everyone in all localities.

Participatory implementation of the SDGs. A local-to-global outlook towards the SDGs can incorporate more people in localizing action plans. Spatial enablement and literacy put all members of society in contact with geospatial information and services, consequently engaging more people and data in reaching the SDGs [21]. Citizens are producers and users of spatial data, however, if spatially enabled, they can utilize spatial information to devise solutions and contextualized implementation methods at local, national and global levels.

Comprehensive monitoring of the SDGs. Measuring and monitoring socio-economic SDG indicators, specifically land-related indicators, require spatially enabled datasets (data collected through surveys, crowdsourcing, and censuses) to achieve the SDGs at local and national levels [3]. Statistical and geospatial data are also critical for comprehensive decision-making across different scales of governance [15]. Monitoring the SDGs requires cross-national, cross-sectoral, and cross-scale monitoring, which can be accelerated by incorporating spatial data and technologies.

Spatially enabling the SDGs is the process of uniting the various features of spatial enablement with the SDG framework by employing spatial information, technologies, and services as a common force to confront social, economic, and environmental challenges everywhere. However, the SDGs will not reach everyone if there is a gap in connecting the social, economic, and environmental aspects of challenges, stakeholders and societal actors, resources, and technologies across local, national, and global scales.

4.3 Narrowing the Connectivity and Spatial Gap

There are clear overlaps between spatial enablement and the SDGs: engaging all members of society, addressing the social, economic, and environmental layers of problems, using spatial information to locate events, implement solutions, and monitor progress. However, the SDGs are often examined in silos, overlooking the social, economic, and environmental interlinkages embedded in each SDG [2]. Drawing from the main entities of spatial enablement identified in [7] and the sustainable development data flow outlined in [21], Figure 4.1 illustrates the interlinkages of spatially enabled SDGs. Incorporating these links in research or implementation strategies can narrow the connectivity gap by promoting transdisciplinary planning, cross-sectoral mobilization, and transnational partnerships:

Transdisciplinary planning: the SDGs cover a wide range of issues pertaining to social, economic, environmental, political, technological, and other areas of development. Incorporating the middle layer of Figure 4.1 includ-

FIGURE 4.1
Integration of spatial enablement in the SDGs

ing data, technologies and systems, infrastructures and platforms, policy, and standards connects people with the tools, methods, and strategies needed to tackle the multidimensional challenges of the SDGs. This connection is created across different scales, sectors, and domains, enabling the continuous and consistent path through transdisciplinary research and action plans.

Cross-sectoral mobilization: the SDGs require all members of society with different socio-political and socio-economic responsibilities to be involved in achieving the goals. Spatially enabling the SDGs engages citizens and breaks the government, private sector, academic, and non-profit silos to facilitate cross-sectoral cooperation to comprehensively address the social, economic, environmental, and governance layers of the SDGs. Therefore, mobilizing sectors and members of society in spatial enablement and sustainable development (inner layer of Figure 4.1) can result in more efficient and effective efforts towards meeting the SDGs.

Transnational partnership and collaboration: poverty, clean energy, water and sanitation, equality and justice, education and other social, economic, and environmental problems in the 2030 Agenda are present, to different degrees, in developed, developing, and underdeveloped nations (outer layer of Figure 4.1). Financial markets rivers, forests, and other natural recourses transcend national borders. Therefore, to fulfill all the SDGs for everyone in

all localities requires multinational partnership and collaboration to muster resources, technologies, and people needed to achieve the goals in all nations.

The integration of spatial enablement in the SDGs results in forming connections between the human, technical, and sustainability layers of society order to contextualize all dimensions of a Goal in its local, national, and global circumstances. One of the implications of narrowing the connectivity gap is understanding that the interlinkages within the SDG framework reveal how people and the social aspect are at the core of spatial enablement and sustainable development, and technological aspect is a tool that facilitates progress.

4.4 The Social Impact of Spatially Enabling the SDGs

The SDGs hold different social, economic, and environmental weight and can benefit from spatial enablement in different capacities. In this framing, UN-GGIM and the World Bank, 2018 have identified some of the social, economic, and environmental benefits of integrating a geospatial information framework. Building on their analysis, Table 4.1 explains how spatial enablement can socially impact the SDGs and strengthen community resilience.

TABLE 4.1: Social impact of spatial enablement characteristics on the SDGs

SDG	**Social impact of spatial enablement**
Goal 1	Poverty mapping and engaging citizens in the process can help stakeholders alleviate poverty. Moreover, land tenure security and knowledge of land rights can affect income levels; land is a source of income, food, and shelter.
Goal 2	SDIs can manage and share information about food resources and agriculture to reduce food insecurity among communities and improve agricultural production. Land tenure security improves accessibility to agricultural land as well.
Goal 3	Spatial assessment of disease outbreaks can help governments and international organizations track and prevent the spread of communicable diseases. Spatial platforms can also increase access to medical facilities and supplies.
Goal 4	Integrating spatial literacy and awareness in school curricula can step up citizen involvement in decision-making and implementation phases, in addition to increasing knowledge of land rights, particularly for vulnerable members of society.

Goal 5	Mapping gender inequalities and social phenomena that exacerbate them can support policies that enrich women's welfare. Spatial literacy and knowledge of land rights can empower women and reduce the adverse effects of economic and environmental shocks.
Goal 6	Water management requires geo-referenced information, particularly for location-specific decision-making. Locating transboundary water ecosystems and land management also effects community access to clean water and water resources.
Goal 7	Spatial assessment of resources can identify regions that lack access to clean energy and locate different energy resources. Lack of land tenure can also affect the development of energy infrastructures and access to energy.
Goal 8	Analyzing the spatial distribution of economic activities, gaps, and needs can raise employment rates. Moreover, utilizing geospatial services to enhance access to social services and land information can increase economic growth.
Goal 9	Spatial data can advance soft and hard infrastructures, including SDIs, by connecting transport, energy, financial, health, educational and other services to communities. Secure land tenure will allow the efficient development of physical infrastructures.
Goal 10	Knowledge of the spatial distribution of socio-economic inequalities can contribute to forming laws, policies, and practices that promote equality and equal access to rights, services, and resources.
Goal 11	Authoritative and citizen-generated spatial data can reduce crime rates, identify safe public transport stops, upgrade and transform informal settlements. Securing land tenure can also foster the development of inclusive urban infrastructures and housing.
Goal 12	The spatial tracking of waste management and efficient use of natural resources can reduce the release of contaminants, pave the way for a safer ecosystem and establish sustainable land use patterns for energy and food production.
Goal 13	Disaster risk models, spatial data sharing systems and land tenure can minimize climate impact, accelerated disaster response and early warning systems, managing safe migration, upgrade hazard mapping, and reduce socio-economic vulnerabilities.
Goal 14	Spatial data on fisheries and natural resources can assist with halting illegal marine activities and boost tourism. In addition, information regarding land-based activities can affect marine ecosystems.

Goal 15	Earth observation and geospatial data can map, measure, and monitor land use and natural resource management to improve the conservation of terrestrial ecosystems, which reduces economic loss and secure social and ecological sustainability.
Goal 16	Institutions across different sectors and scales can elevate inclusivity by reforming land administration and land rights, geospatial infrastructures, systems, standards, and policies.
Goal 17	The development of geospatial technologies, availability of spatial data for citizens, industry, and governments, and integration of geospatial frameworks in the SDGs requires cooperation at all levels of government and multi-stakeholder partnerships.

Many of the social elements of the SDG framework in Table 4.1 are connected to land and land administration. Inclusive land management and administration is a requirement for sustainable development [23]. Land-related information, therefore, makes spatial enablement at the government level more inclusive, while empowering communities by creating social equity and economic opportunities [32]. With 68 percent of the world's population living in urban areas by 2050 [14], land information is essential for SDG 11, which tackles both cities and urban communities facing poverty, disaster shocks, housing crisis, and other inequalities. Therefore, land ownership information is fundamental to spatial enablement which can sustainably manage people's relationship to land.

4.5 Land: The Driving Force of Spatial Enablement for the SDGs

Rising urbanization, natural disasters, increasing inequalities, and poverty are some of the pressing global risk of our time [5], which cause severe setbacks for urban communities, land use, and land related activities. Land ownership information, one of the six elements of spatially enabled society, can significantly strengthen the resilience of urban communities by managing and monitoring the multidimension effects of land on urban growth. To foster social cohesion in urban settings, land ownership information significantly contributes to dealing with SDG 1, SDG 5, and SDG 13:

Poverty alleviation (SDG 1): effective documentation of land rights and parcel information can be used to manage land disputes, policy and decision making, and support formal land markets that provide the means to reduce poverty [26]. Community members can get involved in these practices by providing volunteered information where authoritative data is not

available [16]. Subsequently, land ownership directly affects income levels and economic growth [11].

Gender equality (SDG 5): ownership and control over land can empower women by reducing dependency on men for financial assistance and increase opportunities for economic and social activities [28]. Registration systems make secure land rights and ownership possible, which in turn facilitates equal access to economic resources, health services, inheritance and other socio-economic advantages. Therefore, equitable access to land, housing, and basic services through land administration functions such as securing and transferring land rights make sustainable urban development more inclusive [26].

Disaster risk reduction (SDG 13): with more frequent and intense disasters, land ownership information is of utmost importance; disasters can destroy land and land records, kill title-holders and erase physical land boundaries. Community participatory methods and satellite imagery can indicate ownership and property location after the occurrence of a disaster [34], which strengthens community resilience to disasters. Therefore, secure land rights can protect community access to shelter, food and other services, when people are most vulnerable after a disaster.

Impediments to even urbanization and secure land rights can have long-term effects that transcend time and location. Land information can strengthen the resilience of our ecosystems by facilitating infrastructure development, cohesive decision-making on best policies, the establishment of just institutions, and disaster prevention strategies that meet community needs. To fulfil these needs by 2030 for everyone, we need to have a comprehensive understanding of the complexity and links between social, economic, environmental, political, spatial, and cultural layers of present and future needs.

4.6 Conclusion

The disturbances inflicted by natural and human-induced events affect the interactions between social, economic, environmental, and governance sectors. Integrating a geospatial framework in sustainable development can reinforce the inclusivity principles of the SDGs by locating, monitoring and overcoming the challenges we face. Further research is needed to identify localized spatial applications and their impact on each of the SDGs. However, realizing the role of spatial enablement in the 2030 Agenda and understanding the impact of spatial enablers such as land administration and management will enable a holistic approach to effective, efficient and innovative solutions for delivering the SDGs.

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Part II

Enhancing SDGs Connectivity and Disaster Resilience

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5

Leveraging National Land and Geospatial Systems for Improved Disaster Resilience

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This chapter presents 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.

5.1 Introduction - Supporting SDGs With Land and Geospatial Information

National land administration systems and geospatial data infrastructure are fundamental for disaster risk management. They play a key role in facilitating tenure, land use, land valuation and zoning information, for planning, monitoring and implementing responses before, during and after disasters. The input

of this information enhances resilience capabilities and enables stakeholders to carry out actions required for disaster mitigation and preparedness. With disaster events around the world increasing in frequency and severity, better access to this information is critical to disaster risk management activities.

Achieving the SDGs is parallel with establishing safe and resilient communities that have effective disaster risk management practices in place. Every SDG is related in some way to disaster risk management and requires disaster resilience to some degree. Land and geospatial information is critical to the successful implementation of the SDGs through the provision of reliable land data that provides land tenure security for owners and individuals with interests in land, and for land value, use and development dimensions at the local scale that can guide resilient actions [7]. By addressing the maturity and completeness of land and geospatial systems, and the level of integration into disaster risk management activities, the progress towards establishing a foundation for best practice land management can be understood, and areas for focus can be identified.

This chapter is a resource for enhancing resilience – and in particular, resilience to disaster events in a specific country context by improving the impact of existing land and geospatial systems. It explores the role that land and geospatial systems play within a country, and highlights ways that disaster resilience can be significantly improved for stakeholders, particularly at the community level, through use of existing land and geospatial information and resources. Resilience is the ability of a system, community or society exposed to hazards to resist, absorb, accommodate to, and recover from the effects of a hazard in a timely and efficient manner [9]. In the context of land, land resilience translates to the resilience of land and property and the people to land relationships that exist to recover to the extent that land tenure, value, use and development activities can effectively take place.

5.2 Addressing Global Problems With Land and Geospatial Systems

National land administration systems and geospatial data infrastructure act as the country's source for recording people to land relationships. The stability of these systems and the security of tenure they provide enables those who have legal rights in land to be confident that those rights can be assured even in the event of a disaster. This security supports wider resilience by providing confidence that if land is physically left – as required by disaster events that demand evacuation, that owners are protected against land grabbing and other activities that would otherwise threaten their right to land.

In addition to providing security to the community, the land records themselves need to be made resilient from any physical impacts that could destroy

them. It is critical that best practices for data management are adopted to ensure information is digitally recorded and backed up so wider resilience of the community can be supported.

When disasters displace people, land records and geospatial data are key to protecting property rights and building resilience. In 2017, droughts, floods, hurricanes, and other disasters displaced over 18 million people [2]. When people are forced to leave their homes behind, land records offer critical protection of their property rights. This is crucial, since land and homes are usually the main assets that people have. Land and geospatial information are key to ensuring that land records are comprehensive and secure. It informs the what, who, where, how much, and other key attributes of a property. Without this information, it is almost impossible for countries to develop proper disaster response or preparedness plans.

In a disaster situation, comprehensive land and geospatial information and systems can secure the recovery of economic activities by providing accessible and instantaneous data about a disasters impact, value of losses, beneficiaries, as well as the levels of appropriate compensation and investment required to restore activities. In fact, land and geospatial information play an important role in all phases of disaster risk management, namely: disaster prediction (simulation and visualization), prevention, preparedness and mitigation, emergency response, evacuation planning, search and rescue, shelter operations, and post-disaster restoration and monitoring. Moreover, robust land and geospatial systems can help increase resilience by providing detailed and comprehensive information about the earth's surface. This information demonstrates physical hazards with detailed geographical impact areas, as well as tenure and use, and property assets and their values, to guide development of more effective policies, land use planning, and investments.

5.3 Global Land and Geospatial Systems

Global land and geospatial systems are important national resources. They contribute to stability and economic growth by providing security and surety around people's greatest assets – land and property. A good land system is made up of an effective land administration system and supported by geospatial information and systems.

When building resilience to disasters, establishing a mature land administration system prior to a disaster event is essential to ensuring a fast and effective recovery. Disasters can result in the loss of official records concerning land ownership, which is why land administration systems are essential to early recovery. They can support tenure security, settlement planning and the transition to sustainable development. Improvements in tenure security and land use practices can foster resilience to disasters through increased food

security and environmental sustainability. Conversely, the mismanagement of these issues can increase vulnerability to disaster through unsustainable land use and insecurity of tenure [8]. Additionally, secure property rights include the ability for betterment of societal infrastructure, such as road paving, street light installation, and the development of sewerage systems, all of which are made possible through land tax revenue [6]. There also needs to be more institutional collaboration, interoperability and integration at the national level. This needs to happen across the various national data information systems and platforms that exist to support the development and maintenance of geospatial information for improving societal infrastructure [3].

In striving to achieve a mature land administration system that supports resilience to disasters, a number of issues can arise. For example, an inefficient and ineffective land registration process, which can be compounded by an inoperative land information system, an incomplete and/or outdated cadastre, a lack of trained surveyors to conduct high-quality land surveying, and absence of geospatial data sharing protocols. Situations like this contribute to difficulties in tax collection, distort land markets, result in poor urban planning, and also undermine the associated disaster risk management activities.

In cases like this, and in order to improve resilience to disasters, countries should aim for:

- A complete cadastre
- Establishment of effective land and property rights
- Establishment of appropriate land policy
- Restoration of land records
- Development of a legitimate legal framework and adjudication
- Protection of women's land rights

Working towards measures like these can result in positive outcomes, such as:

- Addressing current land and property disputes, evictions and discrimination
- Developing proposed institutional and normative frameworks, including housing, land and property Directorates
- Allocation of land use for temporary purposes (such as shelter)
- Identifying and securing the land records
- Servicing and management of the emergency
- Supplying information to those who have lost their property rights
- Assessing the state of the land records, institutions and problems.

- Reduction of land disputes

National land and geospatial information can help build disaster resilience. However, we need to better understand the role of such information at the local level, the responsibilities of the institutions that govern land data, and the impact of land and geospatial data on the overall resilience of society.

5.4 Working Towards the SDGs: Achieving Land Resilience

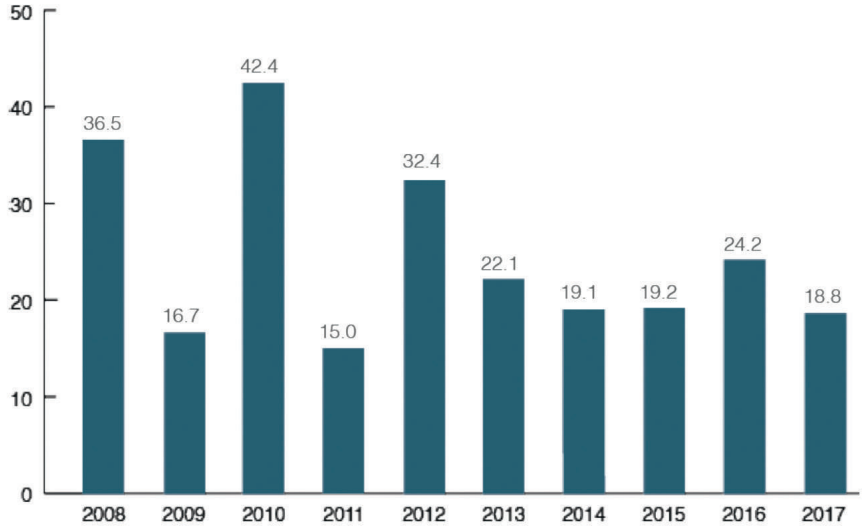
Land is the single greatest resource in most countries, and access to land, security of tenure and land management have significant implications when considering the challenges faced by humanity today. As a finite resource, land – and property, are the main assets of people, and therefore the impact of disruptive events such as disasters, have significant effects on the livelihood of citizens worldwide.

These major disaster events cause large numbers of people to be displaced. Between 2016 and 2017, over 18.8 million people were displaced as a result of disaster events. When disasters displace people, land records and geospatial data are key to protecting their property rights and building resilience.

Disasters are events increasing in frequency and severity and providing countries, worldwide, with an increased impetus to address these events. They are not only having devastating impacts on the world's economies, but, most importantly, on the main assets of their citizens: land and property. In addition to the initial impacts of a disaster, the ongoing and secondary impacts, which can cause major disturbances, need to be considered too. For example, it is often necessary for homes and fields to be abandoned during disasters, however, returning may be restricted due to insecure tenure and the inability to prove prior occupation. Once access to land (a core social safety net) is lost, resuming livelihoods becomes challenging or even impossible, which consequently, increases vulnerability. Families face the prospect of duress selling of assets at reduced prices and moving to informal urban settlements.

There is wide recognition that national land administration systems and spatial data infrastructures are fundamental for disaster risk management. They play a key role in facilitating pre and post disaster tenure, land use, land valuation and zoning information within a unified geospatial platform for planning, monitoring and implementing responses. The input of this information enhances resilience capabilities and enables stakeholders to carry out required mitigation and preparedness actions.

Land and geospatial information can also assist with disaster reduction, risk reduction, preparedness, mitigation and emergency response. It can also expedite recovery operations by providing data on the impact, value of losses,



Source: Extracted from Internal Displacements Monitoring Centre and Norwegian Refugee Council (2018)

FIGURE 5.1
New human displacements due to disasters (2008-2017) [2]

and the investment needs for recovery and reconstruction. Better access to information, along with more secure tenure, yields land use and management decisions that take resilience into account and reduce vulnerability, which can result in improved land resilience and overall resilience to disasters.

Sharing this information with disaster risk management agencies and enabling them to harness this valuable data in their planning and operations enhances the overall process and supports government-wide agendas. However, in many contexts, there is a disconnect between a number of these key elements. In order to achieve land resilience, available land and geospatial resources need to be applied and continually improved upon to meet the needs of the community through the application towards disaster risk management activities.

In order to get to this point and achieve land resilience, three critical elements need to be founded within a country: a mature land administration system, comprehensive geospatial data and systems, and established relationships for sharing with disaster risk management agencies.

In addition to having these elements in existence within a country context, the land administration system, geospatial data and systems need to also be physically resilient to disaster. In contexts where land administration is primarily paper based on not digitally recorded a large vulnerability is present.

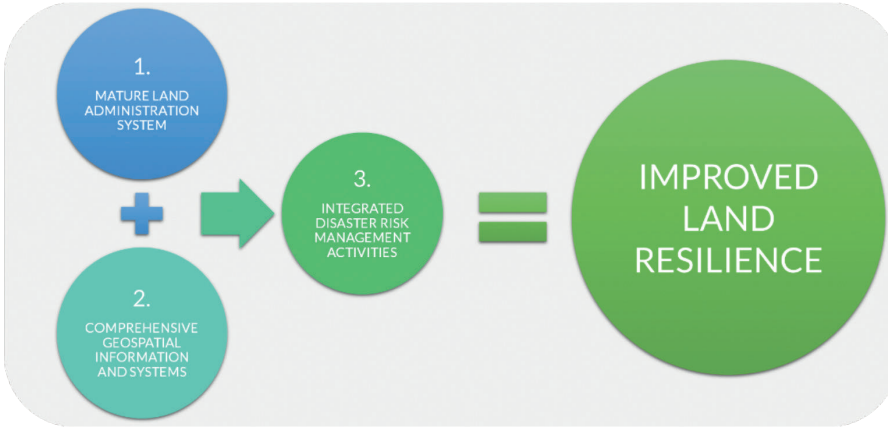


FIGURE 5.2
Key elements for improved land resilience

Equally, geospatial data and systems that are not adequately maintained or backed up are not resilient to an event that may impact its physical location. Securing both the information itself to make it resilient and leveraging the information to support resilience activities are key priorities.

5.5 Global Development Frameworks

Several key initiatives aiming to build resilience to disasters have emerged around the world in recent years. Many of these initiatives tackle a broad range of issues at a number of levels ranging from global or national down to local and community levels. In particular, the 2030 Agenda for Sustainable Development, the Hyogo Framework for Action, and the Sendai Framework for Disaster Risk Reduction aim to substantially reduce the risk of disaster and losses through the implementation of strategic goals and integrated and inclusive measures that prevent and reduce hazard exposure and vulnerability to disaster, increase preparedness for response and recovery, and thus strengthen resilience. They also outline key points that relate to improving resilience to disasters, as well as highlighting the positive effects that national land and geospatial systems can have. In addition, the Integrated Geospatial Information Framework [3] builds on many of these ideas with a focus on geospatial information and how it can be improved to support global development.

The 2030 Agenda for Sustainable Development outlines a need for new data acquisition and integration approaches, including supporting developing countries to strengthen the capacity of their national data systems to ensure

access to high quality, timely, reliable and disaggregated data [5]. The report identifies a series of goals and indicators to assess and measure the progress of development in these areas. This includes national land and geospatial information, and the application of this data to address the identified sustainable development goals (SDGs).

The Hyogo Framework for Action and the Sendai Framework for Disaster Risk Reduction both respond to global issues around disaster risk management, improved resilience and sustainable development. The Hyogo Framework for Action underscores the need for, and identifies ways of, building the resilience of nations and communities to disasters. Sustainable development, poverty reduction, good governance and disaster risk reduction are identified as mutually supportive objectives. It puts forward that in order to meet the challenges ahead, there must be accelerated efforts to build the necessary capacities at the community and national levels to manage and reduce risk [9]. Further to this, within the Hyogo Framework for Action, land issues were established as one of the key priorities for the period of 2005-2015, and have been gaining momentum within the disaster risk management community in recent years.

The Sendai Framework for Disaster Risk Reduction follows on from the Hyogo Framework for Action. It aims to substantially reduce the risk of disaster and losses in lives, livelihoods and health and in the economic, physical, social, cultural and environmental assets of people, businesses, communities and countries. It works to achieve this through the implementation of integrated and inclusive measures that prevent and reduce hazard exposure and vulnerability to disaster, increase preparedness for response and recovery, and thus strengthen resilience [4]. The Framework has identified seven global targets which address areas, including: global disaster mortality; number of people affected by disaster; direct disaster economic loss; damage to critical infrastructure and disruption to basic services; creation and implementation of disaster risk reduction strategies; international cooperation; and availability and access to multi-hazard early warning systems and disaster risk information and assessments. Learning from the experience of implementing the Hyogo Framework, the Sendai Framework has identified four areas requiring further focused action within and across sectors by States at local, national, regional and global levels. These four areas are:

1. Understanding disaster risk: comprehending all the dimensions of vulnerability, capacity, exposure of persons and assets, hazard characteristics and the environment so that the knowledge can be used to inform risk assessment, prevention, mitigation, preparedness and response.

2. Strengthening disaster risk governance to manage disaster risk: Fostering collaboration and partnership at national, regional and global levels.

3. Investing in disaster risk reduction for resilience: Essential investments to enhance people, communities and the environment.

4. Enhancing disaster preparedness for effective response and to 'Build Back Better' in recovery, rehabilitation and reconstruction: taking the opportunity to strengthen and enhance all phases of disaster risk management

The overall focus is to prevent new disasters and reduce the existing disaster risk through the application of prevention and reduction measures to economic, structural, legal, social, health, cultural, educational, environmental, technological, political and institutional areas. To achieve this effectively, enhanced implementation capacity, and strong country commitment that is facilitated through political leadership is required.

In addition to the above frameworks, the Integrated Geospatial Information Framework released in 2018 by the United Nations and the World Bank complements the above agendas, which unequivocally call for globally coordinated actions in new data acquisition and integration approaches [3]. The vision and mission of the IGIF is to address the SDGs and note that strategies and frameworks around the use and management of geospatial information will be required to realize some of these goals, and within the context of disaster risk management, geospatial information will play an important role in developing policies, strategies and legislative arrangements to future challenges faced.

The purpose of the IGIF is to guide the development and strengthening of geospatial information, as well as the management of relevant infrastructures in developing and developed contexts. Through the nine strategic pathways outlined, we can glean a way to deliver sustainable social, economic, and environmental development through the implementation of integrated geospatial information systems. The strategic pathways are underpinned by a series of principles for geospatial information that represent key characteristics and values: Strategic enablement; Transparent and accountable; Reliable, accessible and easily used; Collaboration and cooperation; Integrative solution; Sustainable and valued; Leadership and commitment. These principles promote consistent geospatial information management, resulting in more open, accountable responsive and efficient governing [3].

5.6 A Roadmap for Building Land Resilience

A Roadmap for improving land resilience within a country context has been developed. The roadmap utilizes a number of tools developed from the project *Improving Resilience and Resilience Impact of National Land and Geospatial Systems* [1] to assess the maturity of land and geospatial systems within a country context. The Roadmap is shown below, and is achieved through the implementation of the land resilience tools:

- The Contextual Analysis Questionnaire is an operational tool used to assess the current status of land and geospatial systems within a country.
- The Pre and Post Disaster Recommendations for Land Resilience identifies key resilience indicators for land and geospatial organizations.
- The Land Resilience Maturity Index Assessment is a technical tool for quantifying the maturity of a country's land and geospatial systems in relation to land resilience.
- The Country Action Plan Template brings together the outputs of the three tools to delineate the dimensions to focus on for improving and enhancing the overall land resilience of a country.

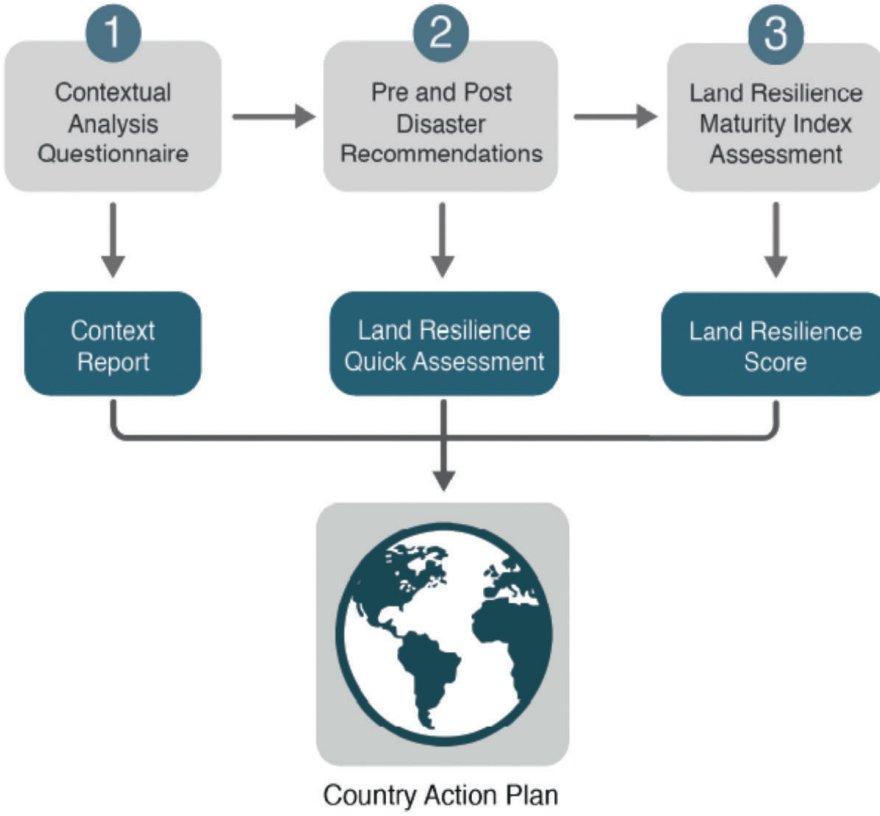


FIGURE 5.3
The Land Resilience Roadmap

The Roadmap facilitates the understanding of:

- how resilient land and geospatial systems are to disasters events

- to what extent land and geospatial systems are able to contribute support to external applications such as disaster risk management activities
- areas that land and geospatial systems could improve or enhance to support disaster risk management functions

By following this Roadmap, the current level of maturity of the land administration systems, the comprehensiveness of geospatial systems, and the level of integration of these systems with disaster risk management activities within a specific country context can be determined which enables areas requiring attention to be identified and addressed, which is turns supports improvements to current practices and overall improved land resilience.

5.7 Conclusion

Improving land resilience starts with a desire from the community for a better approach to managing land. In the context of disasters, often specific events highlight the need for a change or outline situations where significant problems arise. This chapter highlights the importance of land and geospatial information in achieving land resilience and presents a way to understand the current arrangements of land and geospatial information to improve current practices.

Action is required though. Individuals and organizations much work to overcome sharing, integration and interoperability challenges, make better decisions, promote transparency and act cohesively to improve land resilience. In particular, the physical land and geospatial information itself. Though this information and systems may be vulnerable to a wide range of hazards and disaster events, there are many ways to enhance their resilience and significantly reduce any potential loss. Best practice guidelines along with suggestions offered in this chapter are key to securing the valuable land and geospatial information that upholds many other land resilience practices.

The rich land and geospatial resources give us better tools to anticipate, plan and respond to disaster related problems. But decision makers and stakeholders need to work hard to help to ensure that all of this information leads to effective action. This involves developing better integration strategies across organizations at all jurisdictional levels to ensure that information can be utilized for activities where it can benefit the larger community. It also means developing ways of encouraging participation in establishment and improvement in wider resilience activities. Finally, it means better tracking of outcomes to keep organizations and stakeholders accountable for their promised actions and so improvements can be observed and celebrated.

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6

Geospatial Information Technologies in Support of Disaster Risk Reduction, Mitigation and Resilience: Challenges and Recommendations

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This chapter presents Geospatial Information Technologies in the context of sustainable development goals (SDGs), in particular, SDG 11 and SDG13. It contributes to the United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM) in its efforts in disaster loss reduction, mitigation and resilience. Particularly, the chapter discusses what these technologies can bring to support the implementation of Sustainable Development Goals (SDGs).

6.1 Introduction

SDGs are conceived for a wide range of issues in local, national, regional, and global contexts. These include the major development issues related to poverty, hunger, health, natural hazards, agriculture, education, and gender inequality. In addition, SDGs cover specific topics such as energy, infrastructure, economic growth and employment, inequality, cities, sustainable consumption and production, climate change, forests, oceans, and peace and security (Figure 6.1).

The objective of this chapter is to (1) participate in the global sharing of experiences on utilizing geospatial information technologies to address disasters

FIGURE 6.1
The global goals for sustainable development

resilience and challenging issues of determining the vulnerability of buildings; and (2) demonstrate examples of the support-integrated geospatial information technologies including earthquake and structural engineering disciplines followed by utilizing drone images for rescue.

This chapter briefs an example on the need of environmental and geospatial information laws and regulations. Finally, recommendations are proposed that might be helpful to other countries having similar issues.

Today's challenges push everyone to ponder how we, as people living on the Earth, should play a role in SDGs to transform research into real life practices for improved condition and a better way of living together in a better world. Geospatial information technology is a collection of information communication tools [34], to store, capture, manipulate, transform, analyze, and generate information related to our planet. This technology is used for global management, and there is no doubt that, in this era of multilateralism with integrated technologies, there is a crucial need today to work together and face global challenges within a defined proposed ecosystem in the SDGs global context.

Based on a UN report, there is an increase in naturally occurring disasters [38]. Currently, earthquakes can occur almost anywhere in the world including Australia, Canada, Chile, China, England, India, Iran, Mexico, New Zealand, Pakistan, the US and many other countries in seismic zones such as Italy and Nepal. While very large earthquakes may still not occur frequently, the frequency of minor or medium-sized earthquakes is increasing. Indeed, some countries are exposed to many minor and major earthquakes annually. It needs significant consideration to formulate the strengthening of buildings against future earthquakes. At present, there are numerous weak structures in many countries particularly in developing countries that are not able to withstand an earthquake. Public and private developers intend to use the scientific methods to prioritize and optimally allocate budget in order to reinforce the structures, because of limited financial resources, time and availability of an appropriate model. It seems logical to renew our structures with mitigation resilience utilizing the integration of geospatial information technology and engineering. Nowadays, there is sufficient data on the effects caused by earthquakes. And recently, there is greater research on the challenges at various scales by using

Geographical Information System (GIS) for emergency response to disasters [7, 25, 10, 11, 40, 33, 32, 31, 37, 4, 13, 36, 3, 36, 20, 16, 21, 24, 39, 29]. For example, Liu (2018) in [30] studied the seismic identification and reinforcement design of building structures of China after the earthquake in Wenchuan in 2008. She suggested some reasonable improvement methods for the future development of buildings. Also, [35] evaluated a number of buildings in Esfahan city and classified the buildings from low-to-high based on their vulnerability to seismic activity and collapse due to earthquakes. The result was that, at present, numerous structures are still not able to withstand an earthquake.

Nevertheless, the integration of geospatial information technologies with engineering parameters to develop a platform has been an interest of researchers for mitigation resilience, quality efficiency, saving costs, and enriching the quality of the hazard mitigation for loss reductions. Most of the current systems are local and have various limitations mainly because of adaptation of the local instruction of building code or any other infrastructure instruction codes [22, 23, 18]. For example, maps cannot be retrieved to represent buildings geospatially correlated with the evaluation parameters. Tools are not in place to screen buildings for potential seismic hazards with the implementation of 3D reconstruction models. The local system is also often based on a particular region and the scalability remains a challenge. In addition, recent advances in computer vision, artificial intelligence, machine learning and robotics combined with geospatial information using digital cameras are suitable tools for many applications such as rescue and emergency management. The use of cheap platforms with low-end imaging cameras makes this technology available to the public. The amount of data in the images is high but this can be provided online during the search and rescue operation particularly when using drones.

In this chapter, examples are presented showing how geospatial visual screening works for pre-earthquake and post-earthquake preparation. There is also a brief section on how drone images help in human search and rescue.

6.2 Why are technologies alone not enough in disasters loss reduction

To protect the environment through technology, there must be global cooperation. Although science and technology have progressed, there has been little changes to the sustainability of the environment and the preservation of our planet. Though technology has been advancing rapidly, many events such as the catastrophic flood of the Dez river in Iran, and the deforestation of mangroves and salinity of water in the Persian Gulf in Iran (Figure 6.2) happen due to the ineffective national and regional policies including a mismanagement of decision makers in the pursuit of nature and the lack of use

of appropriate technology. In conclusion, it seems that at a global level, earth and the environment are at higher risk than before, and the number of disasters are rising all over the world: Natural disasters like earthquakes, floods and storms as well as human related emergencies such as wars and deforestation are ever-increasing.

(a) (b)

FIGURE 6.2
(a) Recent flood in Iran, (b) plantation of mangroves for sustainable environment and desalinization in Booshehr, Persian Gulf, Iran

6.3 Integration of Geospatial Knowledge

With rapidly growing technologies, critical thinking and problem-solving, including a momentum to sustain the continuing development and enhancing skills in practice, are not only supporting the representation of the real-world but also present as a challenge.

These days the requirements of a desired software and hardware product emphasizes on using artificial intelligence and deep machine learning; however, they depend on the applications and needs of the people for creating a sustainable environment and the economic growth in various sectors. It is required to work with big geo-data and geospatial technologies in conjunction with innovative soft computing solutions to develop products in many fields such as engineering, environmental issues, hazards, mapping, and construction support, augmented reality, and real-time asset management to support the business processes and to develop various types of mobile applications and software.

To utilize and implement the integration of geospatial data and techniques with other technologies requires a conceptual framework and also building

platforms to create a full global geospatial ecosystem. Building platforms and services such as GeoEngine (a geospatial rapid visual screening of buildings for developing ecosystems) is allowing digital transformation and enabling countries to support the implementation of SDGs. Different supporting integrated platforms are required to fulfill the needs of stakeholders, communities, citizens and the public at large. In this multilateralism era, the needs for geospatial information in required in daily life.

However, the author's experience in research and development indicated that the software and hardware engineering processes consist of many activities and require application based knowledge. They are requirements and analysis, specifications, software architecture, implementation, testing, documentation, training and support, and maintenance. Therefore, the integrated technologies, including machine learning, computer vision, and artificial intelligence are the best choices towards creating platforms and working to develop smart systems to connect all disciplines. For example, we can connect earth observation systems and geospatial information technologies for full infrastructure projects, and asset management systems implementation. This builds an intelligent world for the future generations in a GeoEngine platforms' ecosystem. Figure 6.3 shows an example of how geospatial information helps rapid visual screening processes and determines the vulnerability of buildings and estimation of risk. Another example is the platform on representing maps and disaster responses. The snapshot of architecture design of the model is illustrated in Figure 6.4.

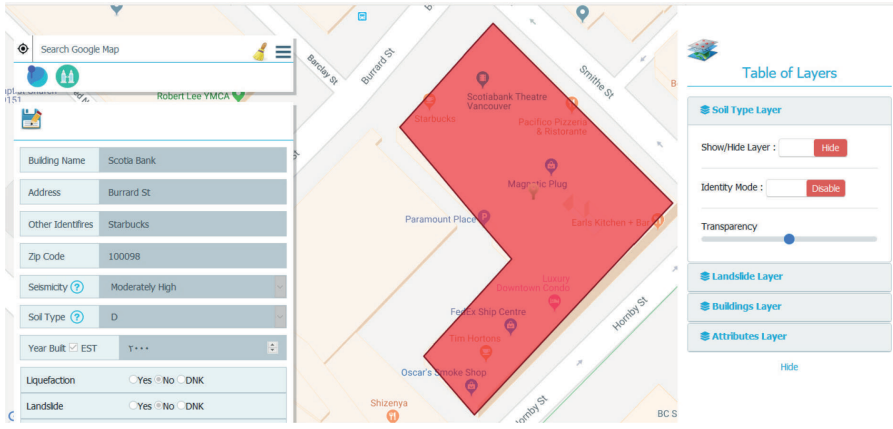

FIGURE 6.3
Screening a building (Geospatial Rapid Visual Screening)