Applications of Geospatial and Information Technologies Toward Achieving Sustainable Development Goals

Chapter · January 2023

DOI: 10.1007/978-3-031-14096-9_1

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Chapter 1
Applications of Geospatial and Information Technologies Toward Achieving Sustainable Development Goals

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Abstract Sustainable development is possible by holistically prioritizing urban and rural development activities by capturing many complexities, constraints, and livelihood opportunities. In this context, United Nations (UN) designed a blueprint containing seventeen interlinked Sustainable Development Goals (SDGs) to address the global challenges, including climate change, environmental degradation, peace, poverty, inequality, and justice. The achievement of SDGs and their universality would be possible through readily available data from affordable sources such as remote sensing images and readily available sources. The spatio–temporal data analysis is crucial for assessing, monitoring, and decision-making and becomes integral in addressing SDG indicators. However, the advancement and availability of an enormous amount of earth observation data increased the need for new methods and techniques. Nowadays, the integration of geospatial technologies along with information and communication technology (ICT) like the Internet of Things (IoT), big data, machine learning (ML), artificial intelligence (AI), advanced sensor networking, and crowdsourcing has made a powerful analytic platform for Spatial Decision Support System (SDSS). This chapter comprehensively reviews and documents the scope and application of geospatial and information and communication technology and its role in action plan formulation toward achieving SDGs.

Keywords Artificial intelligence · Data analytics · Geospatial · IoT · Machine learning · Sustainable development goals (SDGs) · Sensors

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V. P. Singh et al. (eds.), *Application of Remote Sensing and GIS in Natural Resources and Built Infrastructure Management*, Water Science and Technology Library 105,
https://doi.org/10.1007/978-3-031-14096-9_1

Abbreviations

AI	Artificial intelligence
AIS	Automatic identification system
GDP	Gross domestic product
GPS	Global positioning system
GT	Geospatial technologies
IBM	International business machines
ICT	Information and communication technology
IoT	Internet of things
IT	Information technology
LST	Land surface temperature
ML	Machine learning
MOOCs	Massive open online courses
RESAP	Regional space applications programme for sustainable development
SD	Sustainable development
SDGI	Sustainable development goals index
SDGs	Sustainable development goals
SDSN	Sustainable development solutions network
SDSS	Spatial decision support system
SIDS	Small island developing states
UN	United Nations
UNESCAP	United Nations economic and social commission for Asia and the Pacific
VGI	Volunteered geographic information
VR	Virtual reality

1.1 Introduction

Post-industrial revolution during the second half of the nineteenth century had a significant impact on environmental and social equality in Western societies. The series of economic and social crises may be the reason (Fig. 1.1). The ecologist and philosopher Garret Hardin wrote an essay in 1968 entitled "the tragedy of the commons", where he highlighted the issue that if individuals act according to their interests, then it would be going against the common interests of their societies and deplete the natural resources of this planet. In the early 1970s, the term "sustainability" was evolved to describe an economy "in equilibrium with basic ecological support systems". Ecologists have highlighted the alternative way of a "steady-state economy" to address environmental issues. The consequences of what could happen on a planet with limited resources had predicted through computer simulation by the researchers (Meadows et al. 1972, 2013). They have projected that an economic and social collapse will occur by the end of the twenty-first century if man imposes no

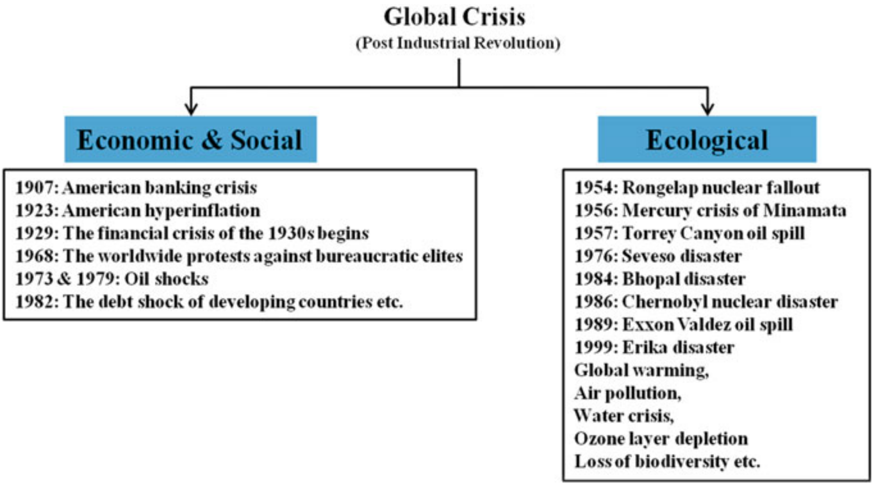

Fig. 1.1 Global economic, social, and ecological crisis after industrial revolution

limits on growth. After more than four decades, these predictions seem to be correct. The environmental degradation due to over-exploitation of limited resources and pollution and its consequences are threatening sustainable development. The idea of sustainable development (SD) was mentioned for the first time in the Brundtland Report in 1987. It was defined as the development that meets the needs of the present without compromising the ability of future generations to meet their own needs. SD is the organizing principle for meeting human development goals while simultaneously sustaining the power of natural systems to provide the natural resources and ecosystem services on which the economy and society depend.

In another way, it shows the path of systematically organizing society so it can exist in the long term considering the preservation of the environment and natural resources or social and economic equity. In 2015, United Nations (UN) set up 17 Sustainable Development Goals (SDGs) to address the various global challenges presented in Fig. 1.2. Sustainable development is possible by holistically capturing many complexities, constraints, and livelihood opportunities that they are subjected to, prioritizing urban and rural development activities. The urban development activities include food security, infrastructure, transportation, energy efficiency, waste management, etc. In rural areas, challenges are mostly related to poverty, agriculture, disasters, etc.

The spatial–temporal data analysis is the key and significant component of the sustainable development framework for the decision-making and prioritization of those activities. The advantage of using geospatial technologies has proven to be effective for achieving targets in many projects. It helps to plan and execute programs systematically and holistically because of its location-based analytics and visualization offered by earth observation technologies. National and international organizations realize the importance and effectiveness of geospatial tools and techniques in

Fig. 1.2 Seventeen SDGs proposed by the UN. Adapted from https://www.un.org

achieving the SDGs. Hence, the UN has formulated the 2030 agenda for SD, including guidelines for appropriate uses of earth observation and geospatial data to measure, monitor, report, and achieve the SDGs. Even sustainable development has included guidelines for proper use of geospatial and earth observation data. Nowadays, integrating geospatial technologies and other technologies like IoT, big data, ML, AI, advanced sensor networking, and crowdsourcing has made a powerful analytic platform for Spatial Decision Support System (SDSS). On the other hand, mobile-based services and integrated IoT networks enable person-to-object and object-to-object communication. Besides, affordable graphics processing units (GPUs) and cloud computing services ease accessibility to massive computing power. In urban areas, location analytics and advanced sensors can gather information about pollution level checking, traffic management, energy, and water usage through an intelligent building, innovative grid technology, etc. Similarly, in rural areas, geospatial analytics helps farmers take appropriate measures related to agriculture development. Besides, it helps the administration build infrastructure like schools, hospitals, banking systems, electricity distribution, and many more based upon spatial analysis. This chapter comprehensively documents geospatial data analysis and synthesis tools and methods and their role in action plan formulation toward achieving Sustainable Development Goals.

1.2 Sustainable Development Goals

1.2.1 Targets

United Nations has proposed a plan entitled “Transforming Our World: The 2030 Agenda for Sustainable Development (Agenda 2030)” to address the global issues at the UN Sustainable Development Summit in 2015. The proposal sets 17 SDGs to manage the global challenges, i.e., inequality, poverty, and the effects of climate change effects. Figure 1.2 shows all SDGs are globally recognized and adopted by many countries considering the feasibility of the plan. SDGs were set up to improve the living conditions and conservation of the environment, especially in developing countries and developed countries too. In order to reach the goal, the Sustainable Development Solutions Network (SDSN) was formed to monitor the activity of countries and regions working toward the implementation of the SDGs and also record the information related to it.

1.2.2 Sustainable Development Goals Index (SDGI) and Its Global Perspective

The effectiveness of the SDGs is determined by the SDGI. Hence, a dashboard has been set up containing a scale from 0 to 100. The “0” and “100” show the worst level of implementation and full compliance with the targets, respectively. The current status of SDGI at a global level is presented in Fig. 1.3.

The World Economic Forum has published a ranking on the performance of each country toward achieving SDGs using SDGI (World Economic Forum (2021). As per the report, countries, namely Sweden (84.5), Denmark (83.9), Norway (82.3), Finland (81), and Switzerland (80.9), have implemented SDGs more effective manner and ranked in the top five for good performance in addressing social and economic issues. However, many African countries like the Central African Republic (26.1), Liberia (30.5), the Democratic Republic of the Congo (31.3), and Niger (31.4) are in the poor performance category. The responsible aspects behind the poor performance of these countries are especially poverty, hunger, education, and peace and justice. Besides, a country like the USA is in the 25th place with 72.7points; Canada is in 13th position with 76.8 points; Australia is in 20th place with 74.5 points, and the UK is in 10th position with 78.1points.

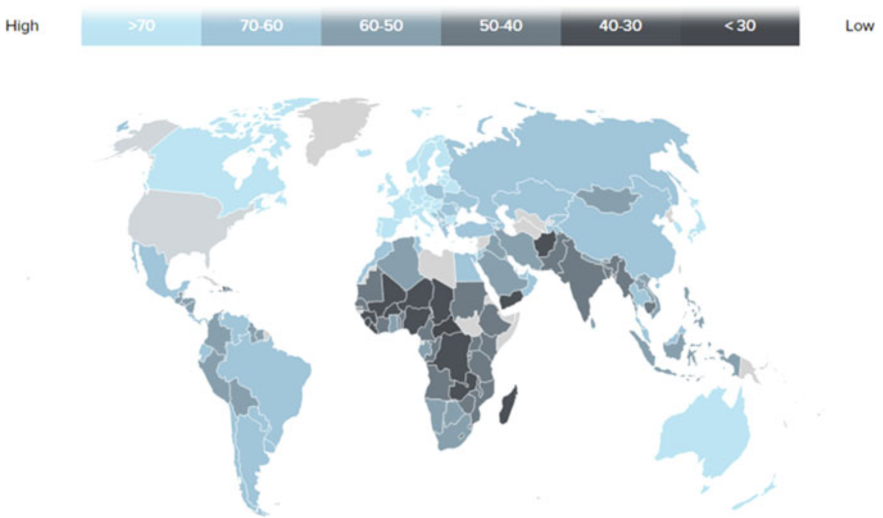

Fig. 1.3 SDGI showing status of SDGs at global level. Data source World Economic Forum (2021)

1.2.3 Impact of COVID-19 Pandemic on SDGs Implementation

The implementation of SDGs became more challenging as the COVID-19 pandemic progressed across the globe. Guillaume Lafortune from UN Sustainable Development Solutions Network Initiative has summarized the key findings of the Sustainable Development Report 2020 on June 25, 2020, and reported that COVID-19 is negatively affecting several goals such as no poverty-SDG 1; zero hunger-SDG 2; good health and well-being-SDG 3; decent work and economic growth-SDG 8; and reduced inequalities-SDG 10. The overall impact of COVID-19 on SDGs is summarized in Fig. 1.4.

1.3 Importance and Scope of Geospatial Technology on SDGs Implementation

Geospatial tools and techniques can play a vital role in achieving targets through their decision support, planning, and monitoring capabilities (Fig. 1.5). Remote sensing satellite is capable of providing a synoptic view and repetitive coverage of the earth's features. Commendable progress has been observed in the scientific world toward

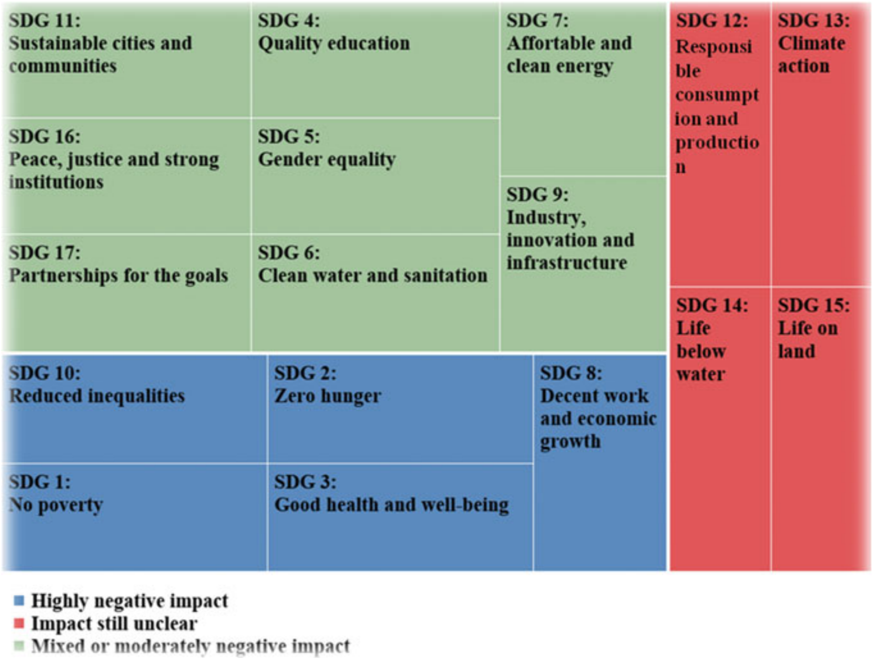

Fig. 1.4 COVID-19 impact on SDGs. Data source Sachs et al. (2020)

using geospatial data at various spectral, radiometric, temporal, and spatial resolutions enabling the usage of the data for various applications (Avtar et al. 2019; Ganguly et al. 2021; Mitran et al. 2021a, b). Hence, images provided by various satellites can be used effectively for the implementation of SDGs and monitoring of their progress.

A set of quantifiable indicators, targets, and observable data specific to each goal has been devised to monitor the progress (Hák et al. 2016). The systematic data observations at the local and community level are required for the subsequent decision-making process, which includes the collaboration of various stakeholders. The quality of data and proper data collection abilities are vital to optimally measuring various SDGs indicators. The UN has also highlighted the issues related to data collection and quality and emphasized the need for a data revolution to enhance data quality (Kharas et al. 2014). In this context, the recent advancement and availability of various geospatial data, techniques, and products could play a meaningful role.

Moreover, there are many satellite sensors, each with particular characteristics, which are essential tools for visualizing and monitoring changes at global and local scales (Avtar et al. 2019). The scientific findings obtained using geospatial approaches can provide a strong basis for policymaking to promote SD in communities at local and regional levels (Habitat 2015; United Nations 2016). Besides,

Fig. 1.5 Scope of geospatial technologies

in situ sensors can be installed to measure these variables at the local scale with a higher frequency. Hence, geospatial tools and techniques can be used very effectively for monitoring most of the SDGs (Dangermond and Artz 2010; Kuffer et al. 2018; Orimoloye et al. 2018; Tatem et al. 2017).

1.4 Application of Geospatial Techniques Toward Achieving SDGs

Geospatial tools and approaches can be used efficiently for monitoring many of the SDGs. However, geospatial data is not yet feasible for all SDGs.

The selected SDGs and geospatial tools and methods to produce appropriate data for monitoring the progress of different indicators of these goals are illustrated in Fig. 1.6. The application of geospatial technology in selected SDGs and database sources supposed to be used for that analysis is summarized and presented in Table 1.1.

1.5 Application of Information and Communication Technology Toward Achieving SDGs

Recent advancements in information and communication technology (ICT) and global interconnectedness show great potential to accelerate SD plans. The aim of using such technologies is to bridge the digital divide and to develop knowledge

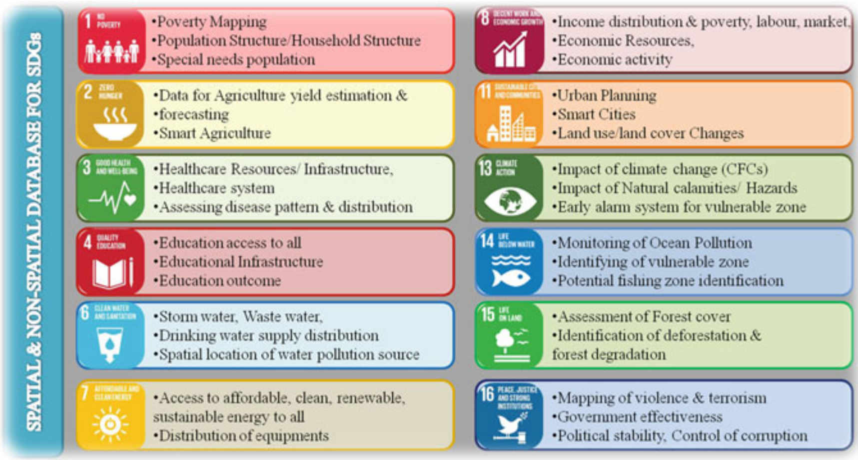

Fig. 1.6 Application of geospatial analysis in some selected SDGs

societies. Digital technology can play a crucial role in monitoring the progress of different indicators of various SDGs. The use of digital techniques could be essential to achieve the SDGs, considering the need for accelerated progress to fulfill the goals by 2030. As technology is revolutionizing, the digital transformation initiatives will radically alter agriculture, energy, manufacturing, transportation, and other industrial sectors of the economy in the next ten years. Although there are many technologies involved in such transformation, a few are especially useful in the context of SDGs. These are big data, AI/ML, and IoT.

1.5.1 Application of Big Data

There is an increasing trend in the volume of data in the world. As per a recent estimate, about 90% of this data has been created in the last two years. Moreover, there is a future projection of an annual increment in the volume of these data by 40%. A maximum share of this output is "data exhaust" or passively collected data from daily interactions with digital products or services, including social media, credit cards, mobile phones, etc. Nowadays, extensive data analysis is standard in the private sector. Several approaches such as predictive analysis, personalized services, and consumer profiling are being used for advertisement, management, and marketing purposes. Similar techniques can be adopted and used to gain real-time insights into people's well-being by targeting aid interventions to vulnerable groups.

Besides, integrating these approaches with various satellite data, geospatial techniques, and data analytics methods can enable more agile, efficient, and evidence-based decision-making if applied responsibly. It could also use to measure and monitor the progress toward achieving SDGs in a way that is both inclusive and fair.

Table 1.1 Geospatial application toward achieving different sustainable development goals

SDGs	Sources of spatial data	Sources of non-spatial data	Geospatial applications	References
SDG 1: no poverty	Satellite imageries	Census data	Poverty mapping	Asensio (1997) and Tatem et al. (2017)
			Identify inequality and spatial disparities	Kuffer et al. (2018)
	Mobile location data		Location-based credit consumption	Eagle et al. (2010) and Soto et al. (2011)
	Thematic data—slope, soil, land use type	Demographic variables, distance, travel time to public resources	Spatial pattern analysis	Okwi et al. (2007)
	Nighttime satellite data, land cover, topography	Population data	Poverty index calculated by dividing population count by the pixel brightness of nighttime images	Elvidge et al. (2009) and Tatem et al. (2017)
SDG 2: no hunger	Temporal satellite imageries		Crop yield assessment	Arroyo et al. (2017)
	Unmanned aerial vehicle (UAV)		Precision farming	Maes and Steppe (2019)
	Landsat imagery and UAV		Estimation of irrigated area	Nhamo et al. (2018)
	Climate data	Hunger population data	Hunger hotspot analysis and impact analysis of climate change	Liu et al. (2008)
SDG 3: good health	Satellite imageries	Healthcare access data	Proximity analysis of healthcare facility for primary care facilities	Rosero-Bixby (2004)
	Satellite imageries, land use and land surface temperature (LST)		Impact of urbanization and LST on health	Orimoloye et al. (2018)

(continued)

Table 1.1 (continued)

SDGs	Sources of spatial data	Sources of non-spatial data	Geospatial applications	References
	Healthcare location data	Clinical data	Epidemiology studies and GIS-based mapping to prevent future pandemics	Lüge et al. (2014) and Maude et al. (2014)
	Location data of COVID-19 infected patient	Details of patient's associated people	GIS-based contact tracing and creation of containment zones	Mishra et al. (2021)
SDG 4: quality education	Education location data	Education infrastructure data	Proximity analysis for basic education facility	Daiman and Goyal (2020)
	Enrollment data	Census data	Assessment of school enrollment and dropout students	Trinidad (2022)
SDG 6: clean water and sanitation	Satellite imagery, land cover, hydrology, geology, vegetation		Assessment of groundwater potential zone using multi-criteria analysis	Machiwal et al. (2011)
	Satellite imagery derived land cover and infrastructure data		Geographical analysis for planning of infrastructure development	Paulson (1992)
	Satellite imagery, land cover, slope, soil type	Land ownership data, weather data	Environmental impact assessment and design infrastructure facilities	Tatem et al. (2017) and Kuffer et al. (2018)
	IRS-LISS-II, DEM, and groundwater data		GIS analysis to prepare proper groundwater management plan for a hard rock terrain	Saraf and Choudhury (1998)
SDG 7: affordable and clean energy	Satellite imageries	Natural renewable energy resources data	GIS analysis for assessing access to affordable, reliable, sustainable, and modern energy	ESRI (https://learn.arcgis.com/en/paths/solve-problems-for-sustainable-development-goals)

(continued)

Table 1.1 (continued)

SDGs	Sources of spatial data	Sources of non-spatial data	Geospatial applications	References
SDG 8: decent work and economic growth	Industry location data	Industry type and category of industry	Assessing predicted economic growth and business growth by industry	ESRI (https://learn.arcgis.com/en/paths/solve-problems-for-sustainable-development-goals)
		Economic growth data	Determine how location impacts on interest rates	
SDG 11: sustainable cities and communities	Very high-resolution satellite imagery, land cover	Population	Image analysis to monitor wastewater treatment at different locations	Ulugtekin et al. (2005)
	Temporal satellite imageries		Urban growth mapping to support energy sector	Haslauer et al. (2012)
	Groundwater data, drainage data	Climate data	Water scarcity mapping and forecasting	Quinteiro et al. (2019)
	Climate data, satellite imageries	Historical disaster data	Geospatial data analysis for disaster management	Lwin et al. (2019)
	Satellite images, ground-based sensors, land use	Pollution data	Monitoring air and water pollution and forecasting future plan	Bonaiuto et al. (2015)
	Temporal satellite imageries, land use	Settlement data, socioeconomic data	Informal settlement mapping and analysis of underlying cause through GIS	Dovey (2015), El-Batran and Arandel (2005) and Karanja (2010)
SDG 13: climate action	Temporal satellite imageries, climate data	Historical events	Building geospatial framework by integrating historical and future data from different sources and merge them together in a single system using GIS	Dangermond and Artz (2010)

(continued)

Table 1.1 (continued)

SDGs	Sources of spatial data	Sources of non-spatial data	Geospatial applications	References
	Remote sensing satellite images		Ozone hole study using remote sensing data and analysis of daily global ozone concentration maps	Avtar et al. (2019)
	Remote sensing satellite images		Monitoring climate change impacts on the glacier and permafrost-related hazards which is potential threat to livelihood of population lives in mountainous areas	Kaab et al. (2006)
	Remote sensing satellite images		Monitoring sea-level changes using spatiotemporal data	Elias et al. (2020)
SDG 14: life below water	Satellite imageries	Marine ecological data	Sustainable use and management of important tropical coastal ecosystems using integrated remote sensing and GIS	Dahdouh-Guebas (2002)
	Remote sensing satellite images for marine study		Spatial monitoring of sea grasses/coastal management	Ferguson and Korfmacher (1997)
	Synthetic aperture radar (SAR) data,, Landsat-8, Sentinel-I		Detecting oil spills using microwave remote sensing images	Yu et al. (2017)
	Satellite imageries, sensor-based data		Identification of potential fishing zones by detecting sea surface height anomaly, ocean temperature, color, etc.	Saitoh et al. (2011)

(continued)

Table 1.1 (continued)

SDGs	Sources of spatial data	Sources of non-spatial data	Geospatial applications	References
SDG 15: life on land	Multi-temporal satellite imageries		Monitoring deforestation	Reddy et al. (2016)
	Global tree cover data		Forest fragmentation study	Riitters et al. (2016)
	GPS data and satellite imageries		Investigation of illegal logging operation	Kusumaningtyas et al. (2009)
	Advanced land observing satellite (ALOS) phased arrayed L-band synthetic aperture radar (PALSAR)		Monitoring above-ground forest carbon stock and carbon sequestration study due to loss of forest	Thapa et al. (2015)
SDG 16: peace, justice, and strong institutions	Satellite imageries	Institution data	GIS analysis to promote peaceful and inclusive societies, provide access to justice, and build accountable institutions	ESRI (https://learn.arcgis.com/en/paths/solve-problems-for-sustainable-development-goals)
		Public policies	Examine racial inequities in unsolved murder cases/criminal activities	
		Data collection for problem areas	Calculate environmental equity for public policy	

The integrated use of geospatial data and big data for achieving SDGs is presented in Table 1.2.

1.5.2 *Application of Artificial Intelligence*

Artificial intelligence is an emerging technique and has a broader impact on many sectors. It can bring about large-scale improvements and transformations in health, agriculture, and education. AI impacts these sectors by delivering government

Table 1.2 Combined use of big data and geospatial data toward achieving different SDGs

SDGs	Big data sources	Type of data	Geospatial sources	Type of data
SDG 1: no poverty	Mobile phone data	Human mobility and socioeconomic levels assessment	Satellite derive information	Poverty mapping
		Estimating poverty and wealth		
		Socioeconomic status		
	Citizen-generated data	Financial assessment		
		Disaster response		
SDG 2: no hunger	Mobile phone data	Food expenditure	Satellite data	Drought monitoring
	Online price data/scanner data/social media data	Consumer price index assessment		Crop yield assessment
SDG 3: good health and wellness	Mobile phone data	Mobility from regions of disease outbreak	Spatial information	Compilation of indicators
		Sources and sinks for diseases		
		Seasonal trends of diseases		
	Search engine data	Diseases trend assessment		
		Identification of hotspots for traffic accidents and preventive measures		
SDG 4: quality education	Mobile phone data	Low literacy zone identification	Spatial data	Compilation of data
	MOOCs data	Policymaking of education		
SDG 5: gender equality	Mobile phone data	Gender prediction	Satellite data	Gender assessment
	Social media data	Gender equality assessment		
SDG 6: clean water and sanitation	Cloud data	Service data assessment	Satellite data	Compilation of indicators
SDG 7: affordable and clean energy	Smart meter data	Determine residential electricity consumption	Satellite data	Detect nighttime luminosity

(continued)

Table 1.2 (continued)

SDGs	Big data sources	Type of data	Geospatial sources	Type of data
SDG 8: decent work and economic growth	Postal data	GDP, economic, and human development	Satellite derive information	Indicator for GDP and economic development
	Search engine data	Identifying unemployment trends and shocks in the workforce	Remote sensing data	Data compilation and assessment
	Mobile phone data	Estimation of seasonal tourism and destination of tourists and inform policies for promote sustainable tourism		
SDG 9: sustainable industrialization	Mobile phone data/GPS data/Google traffic data	Patterns of road usage, pockets of congestion, and determine mobility patterns of population, key factors in the development of infrastructure	Remote sensing data	Data compilation and assessment
SDG 10: reduce inequality	Mobile phone data	Assessing changes in the socioeconomic status of populations	Remote sensing data	Data compilation and assessment
SDG 11: sustainable cities and communities	Mobile phone data	Population hotspots	Remote sensing data	Poverty and slums mapping
		Social events and home locations	Remote sensing data	Land cover/land use changes
		Origin–destination flows	Other spatial data	Data compilation
		Geo-social radius		
		Identification of human mobility after disasters		
SDG 13: climate change	Mobile phone data	Estimation of human mobility after disasters or any climate changes	Satellite data	Changes in the water ecosystem and monitoring of other changes

(continued)

Table 1.2 (continued)

SDGs	Big data sources	Type of data	Geospatial sources	Type of data
SDG 14: life below water	Citizen generated data/cloud data	Assessment of effect of global changes	Geospatial data	Compilation for this indicator
	AIS data	Identify illegal fishing and monitoring of protected marine areas		
SDG 15: life on land	Mobile phone data	Assessment of accessibility and other factor affecting life on land	Remote sensing data	Forest mapping and changes in vegetation
	Citizen generated data	Assessing data compilation		
SDG 16: peace, justice, and strong institution	Mobile phone data/social media data	Crime prediction		
		Criminal activity zoning		

services to citizens, accelerating innovation and enterprise creation, and reducing the cost of public service and the operation of critical infrastructure.

Hence, the formulation of new methods with the inclusion of ML and AI techniques could open a pathway for effective use of the large volume of available data from satellite images and other platforms and enable us to make giant strides toward achieving SDGs.

The high-resolution temporal satellite data, advanced analytical techniques using AI and computing services, can help prevent outbreaks of diseases, map populations, provide insight into gender inequality, enable supply chain transparency, support efficient post-disaster response, and disrupt human trafficking networks. The combined applications of AI with geospatial technologies toward achieving SDGs are presented in Table 1.3. Many countries, specifically in the Middle East and Asia, have already incorporated AI as a critical component of their economic growth and development strategy. The impact of AI on achieving various SDGs (Fig. 1.7) was assessed by Vinuesa et al. (2020) and reported that AI may act as an enabler on 134 targets (79% across all SDGs) through a technological improvement, which may allow overcoming certain present limitations. However, there are 59 targets (35%, also across all SDGs) that may experience a negative impact from the development of AI.

Table 1.3 Application of AI with geospatial technology toward achieving SDGs

SDGs	Data source	Applications	References
SDG 1: no poverty	Satellite images Climate data	Predict and prevent extreme climate-related events	Decuyper et al. (2020)
SDG 3: good health	Population data Administrative map Health data	Predictive modeling to identify populations at high risk for disease	Bi et al. (2019), Dahdouh-Guebas (2002), Istepanian and Al-Anzi (2018), Topol (2019) and VoPham et al. (2018)
SDG 6: clean water and sanitation	Satellite images Local sensor data	Identifying water threats using machine learning algorithm in combination with remote sensing spectral indices	Wang et al. (2017)
SDG 11: sustainable cities and communities	Satellite images Other sensor data	AI-based algorithm to map informal settlements Predictive analysis for disaster management	Ivić (2019)
SDG 13: climate action	Satellite images Climate data	Machine learning and artificial intelligence to aid climate change research and preparedness	Huntingford et al. (2019)
SDG 15: life on land	Satellite images	Machine learning-based image classification to identify land use/land cover changes, forest cover changes	Ganguly et al. (2017)

1.5.3 Application of Internet of Things

In recent years, one of the most well-known technologies growing to new heights and creating a touchstone is the Internet of Things (IoT). The future of interaction has molded things (objects) of the natural world into smart objects (Khanna and Kaur 2020). As it is expected to grow the worldwide connected devices by this decade, it opens up an incredible opportunity to use IoT technology to aid in achieving the 2030 Agenda of SDGs. According to a study conducted in partnership with IoT research firm and IoT Analytics, 84% of existing IoT deployments can achieve the SDGs (Fig. 1.8). Surprisingly, 75% of these projects are focused on just five SDGs (World Economic Forum (2021).

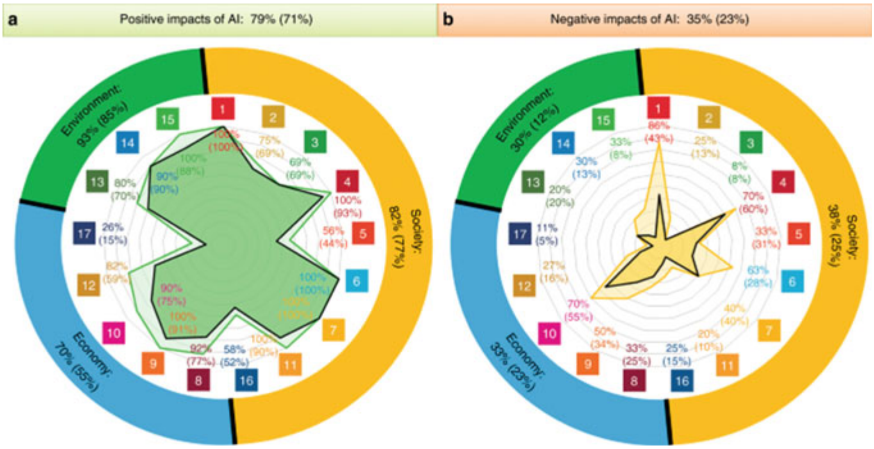

Fig. 1.7 Impact of AI on the various SDGs. Adapted from Vinuesa et al. (2020)

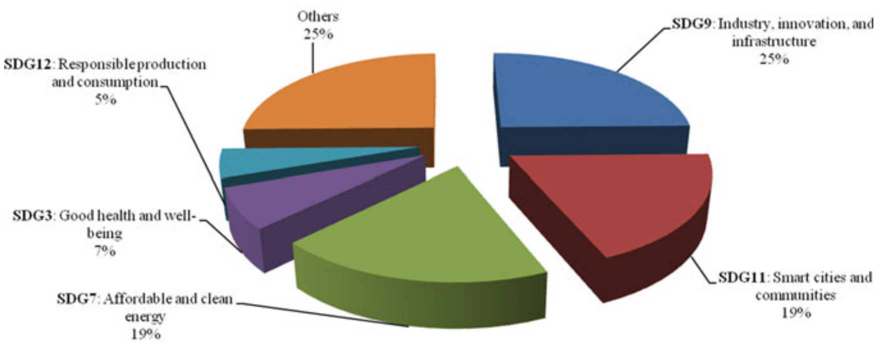

Fig. 1.8 Maximum deployment of IoT in SDGs

The Internet of Things plays a significant role in helping enterprises accomplish this goal. The combination of IoT and geospatial technology significantly improves three specific goals presented in Fig. 1.9.

1.6 Integration of Geospatial Technology with ICT and Its Significance

The advancement of cutting-edge technologies such as IoT, AI, ML, VR, Digital Twins, crowdsourcing, citizen science, VDI, and participatory sensing will alter how we work, live, and think. Geospatial technology is integrated with advanced technologies to create advanced tools for sustainable development and decision support systems at the regional level (Acharya and Lee 2019).

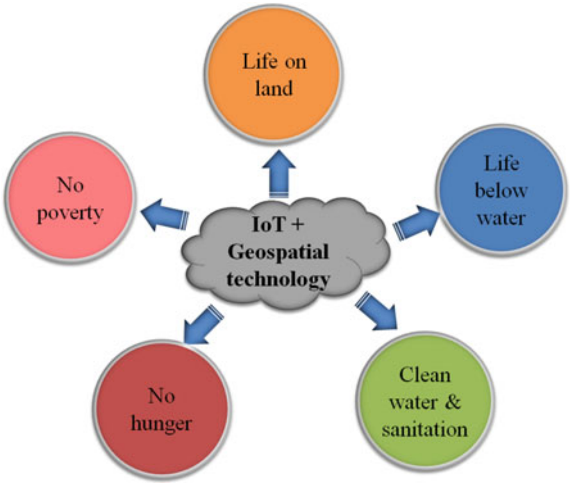

Fig. 1.9 Application of IoT with geospatial technology in SDGs

The challenges in geospatial data involved its acquisition, storage, transfer, sharing, searching, visualizing, and analysis of the data. The facets of big data generally refer to the three V's (i.e. Volume, Variety and Velocity) which is considered as common framework to describe big data (Laney 2001).

The remote sensing big data has numerous unique and solid characteristics; i.e., in the high-dimensional, dynamic state, the data should have nonlinearity characteristics, state, isomer, multi-scale, multi-source, isomer, and nonlinearity characteristics (Liu 2015). Figure 1.10 shows the integration of ICT with geospatial technology.

1.7 Gaps or Challenges

Integrating geospatial technology, i.e., remote sensing and geographical information system (RS and GIS) with information technology (IT), i.e., big data, AI/ML, and IoT, will change how we live, work, and the thought process. Implementing the new technology with advanced tools for sustainable development will change the method of assessment, monitoring, and decision support system. The geospatial data and big data-driven algorithm, AI/ML, and IoT will help prove high-quality, most accurate, real-time integrated, location-enabled analysis with robust decision-making tools.

Nonetheless, with the advancement of the integration of technologies, there are still some challenges and limitations. The challenges exist in various aspects; some are data-related, administration level, implementation level challenges, etc. Developed countries have enough resources, data, and awareness, but many developing countries face significant challenges due to accurate high, definition data, resources, skilled workforce, and limited understanding. Some significant challenges are identified and presented in Fig. 1.11. The challenges related to various aspects are given as follows.

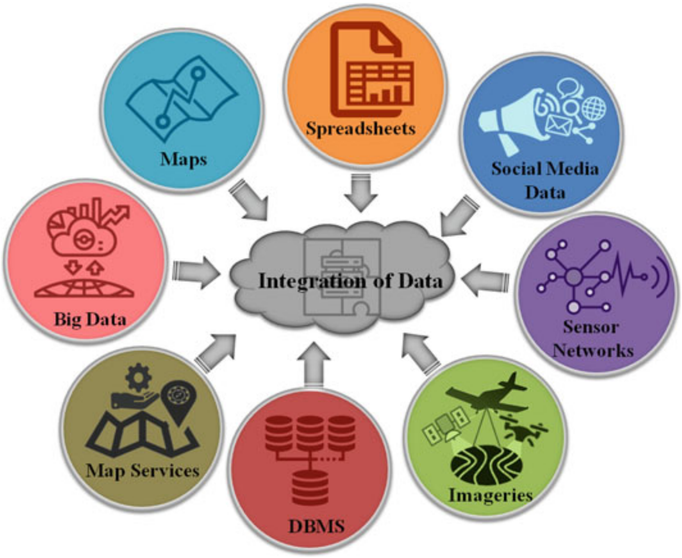

Fig. 1.10 Integration of ICT with geospatial technology

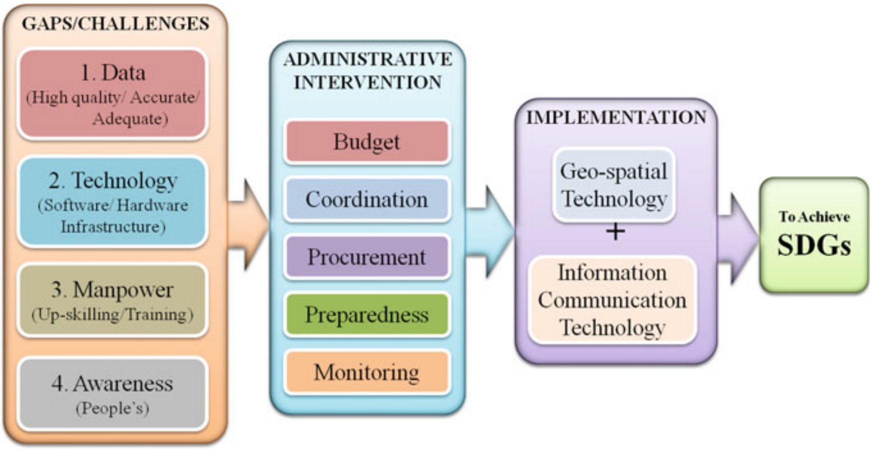

Fig. 1.11 Challenges, intervention, and implementation pattern to achieve SDGs

1.7.1 Data-Related Challenges

Various sources of data are an integral part of accurate analysis. The most critical datasets are RS data produced by many RS satellites and ground sensors. The datasets deal with calibration, quality, interoperability, data processing, visualization, etc. Other factors, i.e., image processing techniques, spectral uncertainty, and images resolutions, affect RS data quality. Mobile phone data, cloud data, citizen generated, etc., used for big data analysis are not accessible. The availability of ground data or secondary data for the specific area will also affect the analysis. Procuring accurate data within a particular time frame is a challenging factor that needs administrative intervention.

1.7.2 Lack of Technology Infrastructure

Technologies are changing day by day with the advancement of tools and approaches. A considerable amount of data needs high data processing power hardware to process high volume data and high capacity of servers. Hence, underdeveloped countries need proper support to get those high-definition systems.

1.7.3 Skilled/Trained Manpower

Advanced technologies, including software, demand highly skilled human resources in IT sectors. Training the existing workforce using traditional analysis methods would be crucial to increasing professional human resources. More specifically, developing countries, including Small Island Developing States (SIDS), may not have sufficient experts and human resources to take advantage of these innovative technologies fully. Countries can strengthen their human resources base and build capacity through regional and international partnerships (UNESCAP 2018) and Regional Space Applications Programme for Sustainable Development (RESAP).

1.7.4 Lack of Awareness

Lack of awareness about data, technology, and new ideas is widespread in developing countries. There are fears among the traditional practitioners regarding the new geospatial and information technology that exists in developing countries, which will slow down the rate of advancement.

1.7.5 Others

Budget constraints in technology, workforce up-skilling, and data procurement are significant challenges in some developing countries. Administrative preparedness and proper coordination with technology advancement are essential to address the significant challenges, and it should be encouraged to achieve the global Sustainable Development Goals.

1.8 Conclusions

- The current chapter shows a comprehensive review of the combined use of geospatial tools/techniques and information/communication technology to achieve SDGs.
- SDGs have been set up to address many global challenges, such as poverty, inequality, climate change, environmental degradation, peace, and justice.
- Achieving SDGs and their universality would be possible through easily available data from affordable sources such as remote sensing images and readily available sources.
- Earth observation plays a crucial role in monitoring the SDGs, given its cost-effectiveness on data acquisition on all scales and information richness.
- Advanced technology/earth observation for assessing, monitoring, and decision-making is integral in addressing the indicators associated with SDGs.
- A sustainable society would be better ensured with a proper sustainable development plan. In this context, the UN has set up seventeen SDGs to achieve the target by 2030. Hence, there will be a future need to develop new methods and techniques to process enormous earth observation data of various sizes, sources, and formats.
- The recent advancement in big data analytics, IoT, AI, etc., could play a meaningful role in reaching SDGs set up by many developed and developing countries through Spatial Decision Support Systems.

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