Geospatial Practices for Sustainable Development in Asia and the Pacific 2020: A Compendium

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Armida Salsiah Alisjahbana
Executive Secretary

Kaveh Zahedi
Deputy Executive Secretary

Tiziana Bonapace
Director, Information and Communications Technology and Disaster Risk Reduction Division

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FOREWORD

The world has grappled with the impact of COVID-19 on people's health and the strain on our economies and societies. In less than a year, the pandemic has threatened to reverse decades of hard-won progress towards achieving the 2030 Agenda for Sustainable Development.

The effective integration of geospatial data, with existing statistics and ground-based information, will be key to delivering the timely data needed for governments, businesses, communities and citizens to make evidenced-based decisions. Spurred by the accelerated adoption of digital innovations, many countries in the Asia-Pacific region are leveraging geospatial information to provide timely evidence and insights for their responses to COVID-19. From basic topographic features on maps, to complex 3D models, geospatial information and remotely sensed data provide far-reaching solutions to the pressing issues facing humanity.

In 2018, ESCAP Member States endorsed the Asia-Pacific Plan of Action on Space Applications for Sustainable Development (2018–2030), an inclusive and country-needs driven blueprint to harness space and geospatial applications and support countries to achieve the 2030 Agenda. Geospatial Practices for Sustainable Development in Asia and the Pacific 2020: A Compendium, provides an overview of the regional status and progress in all six thematic areas of the Plan of Action, based on the contribution of over 100 examples from countries and partners in the region.

I commend these countries for leveraging space applications for sustainable development. In particular, those countries that have been able to move faster than others and continue to generously share their expertise through regional cooperation opportunities.

This compendium demonstrates the diverse use for geospatial information and applications and the vital role they will continue to play in the future. It also highlights the importance of making geospatial data, tools and innovations accessible, available and affordable to maximize benefits for all. Two of the seven key success factors particularly worth highlighting are investing in cultivating national experts and incorporating geospatial information into a range of national institutions and platforms.

I hope that this cross-cutting analysis of country-based examples will promote peer learning and innovative thinking. As underlined in the Data Strategy of the UN Secretary-General, data has become a strategic asset. ESCAP is fully committed working closely with member States and all stakeholders, to implement the Plan of Action, and COVID-19 data-driven responses to build back better and to accelerate implementation of the Sustainable Development Goals in Asia and the Pacific.

Armida Salsiah Alisjahbana
Under-Secretary-General of the United Nations and Executive Secretary of ESCAP

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Contributors from Member States listed in alphabetical order:

Armenia, Ministry of Emergency Situations

Armenia, Ministry of Environment

Asian and Pacific Centre for the Development of Disaster Information Management (ESCAP-APDIM)

Australia, Geoscience Australia

Bangladesh, Space Research and Remote Sensing Organization (SPARSSO)

Bhutan, Department of Geology and Mines

Bhutan, Department of IT and Telecom, Ministry of Information and Communications

Cambodia, ASEAN Coordinating Centre for Humanitarian Assistance on Disaster Management (AHA Centre)

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Cambodia, Ministry of Water Resources and Meteorology (MOWRAM)

Cambodia, National Committee for Disaster Management (NCDM)

Cambodia, National Committee for ESCAP (NC-ESCAP)

Cambodia, National Mekong Committee (CNMC)

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China, Aerospace Information Research Institute (AIR)-Chinese Academy of Sciences

China, Beijing Normal University

China, Institute of Atmospheric Physics-Chinese Academy of Sciences

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China, National Geomatics Center of China-Ministry of Nature Resources

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China, Sun Yat-sen University

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Drought Monitoring System-Sri Lanka (DMS-SL)

Hong Kong, China, Hong Kong Observatory

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Iran, Forests, Range and Watershed Management Organisation

Iran, Iranian Red Crescent Society
Iran, Iranian Space Agency (ISA)
Iran, Ministry of Communications and Information Technology
Iran, National Disaster Management Orgainsation of Iran
Japan, Asia-Pacific Regional Space Agency Forum (APRSAF) Space Application Working Group
Japan, Cabinet Office
Japan, Ministry of Education, Culture, Sports, Science and Technology
Kazakhstan, Gharysh Sapary (KGS)
Laos P.D.R., Ministry of Science and Technology
Mongolia, Information and Research Institute of Meteorology, Hydrology and Environment, Mongolia (IRIMHE)
Myanmar, Department of Meteorology and Hydrology, Ministry of Transport and Communications
National Agricultural Drought Assessment and Monitoring System (NADAMS)
Nepal, Forest Research and Training Centre
Pakistan, National Disaster Management Authority (NDMA)
Pakistan, National Disaster Risk Management Fund (NDRMF)
Pakistan, Pakistan Space Upper and Atmosphere Research Commission (SUPARCO)
Philippines, Ateneo de Manila University
Philippines, Department of Science And Technology (DOST)
Philippines, Manila Observatory
Philippines, Mariano Marcos State University
Philippines, Philippine Council for Industry, Energy And Emerging Technology, Research And Development
Philippines, The Department of Science and Technology-Philippine Council for Industry, Energy and Emerging Technology Research and Development (DOST-PCIEERD)
Republic of Korea, Korea Aerospace Research Institute (KARI)
Russian Federation (the), State Space Corporation ROSCOSMOS
Russian Federation (the), The Ministry of Emergency Situations (EMERCOM)
Russian Federation (the), The Russian Space Systems
Russian Federation (the), The Scientific Center for Operational Monitoring of the Earth
Sri Lanka, Department of Agrarian development
Sri Lanka, Department of Agriculture
Sri Lanka, Department of Irrigation
Sri Lanka, Department of Sri Lanka Railways
Sri Lanka, National Building Research Organization
Sri Lanka, National Physical Planning Department
Sri Lanka, National Water Supply and Drainage Board
Sri Lanka, Rubber Research Institute
Sri Lanka, Sri Lanka Ports Authority
Sri Lanka, Sri Lanka Sustainable Energy Authority
Sri Lanka, Telecommunications Regulatory Commission of Sri Lanka
Sri Lanka, Water Resources Board
Tajikistan, Institute of Water Problems, Hydropower and Ecology-Academy of Science
Thailand, Centre of Agricultural Information-Office of Agricultural Economics
Thailand, Department of Alternative Energy Development and Efficiency (DEDE)-Ministry of Energy
Thailand, Department of Fisheries
Thailand, Department of Marine and Coastal Resources
Thailand, Department of Mineral Resources
Thailand, Department of National Parks, Wildlife and Plant Conservation
Thailand, Department of Public Works and Town & Country Planning
Thailand, Geographic Information Section-Information and Communication Technology Center
Thailand, Geo-Informatics and Space Technology Development Agency (GISTDA)
Thailand, Hydro-Informatics Innovation Division
Thailand, Land Development Department
Thailand, Marine Department
Thailand, National Research Council of Thailand
Thailand, Office of Engineering Topological and Geotechnical Survey
Thailand, Office of the National Water Resources
Thailand, Royal Irrigation Department
Thailand, Thai Meteorological Development – Ministry of Digital Economy and Society
Thailand, Thailand Greenhouse Gas Management Organisation
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Partnering Institutions Contributors listed in alphabetical order:

Asia-Oceania GEO (AOGEO)
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ACRONYMS

ADPC	Asian Disaster Preparedness Center
AI	Artificial Intelligence
AIP	Actionable Intelligence Policy
AOGEO	The Asia-Oceania Group on Earth Observations
APDRN	Asia-Pacific Disaster Resilience Network
APEF	Asian and Pacific Energy Forum
API	Application Programming Interface
AP-IS	Asia-Pacific Information Superhighway
APRSAF	Asia-Pacific Regional Space Agency Forum
APSCO	Asia-Pacific Space Cooperation Organization
ARTSA	ASEAN Research Training Center for Space Technology and Applications
ASEAN	Association of Southeast Asian Nations
ASMC	ASEAN Specialised Meteorological Centre
BDA	Big Data Analytics
BIM	Building Information Modelling
CADIS	Central Asia Drought Information System
CASA	Cooperation on the Analysis of Carbon Satellites Data
CCTV	closed-circuit television
CDDR	Disaster Data Response Mechanism
CHIRPS	Climate Hazards Group InfraRed Precipitation with Station data
CO_2	Carbon Dioxide
COPUOS	United Nations Committee on the Peaceful Uses of Outer Space
COVID-19	Coronavirus disease of 2019
CSSTEAP	Centre for Space Science and Technology Education in the Asia and Pacific
DRR	Disaster Risk Reduction
EO	Earth Observation
ESA	The European Space Agency
ESCAP	Economic and Social Commission for Asia and the Pacific
FAO	Food and Agriculture Organization
FASSSTER	Spatio-Temporal Epidemiological Modeler
FRDP	The Framework for Resilient Development in the Pacific
GEMMA	GIS-Enabled Mapping Modelling and Analysis – Singapore
GEMS	Geostationary Environment Monitoring Spectrometer
GEO	Group on Earth Observations
GEOGLAM	Group on Earth Observations Global Agricultural Monitoring Initiative
GEOSS	Global Earth Observation Systems of Systems
GEP	Global Electrification Platform
GGRF	Global Geodetic Reference Frame
GHG	Greenhouse gas
GIS	Geographic Information Systems
GISTDA	Geo-Informatics and Space Technology Development Agency
GNSS	Global Navigation Satellite System
GOSAT	Greenhouse Gases Observing Satellite
GPM	Global Precipitation Measurement
GPS	Global Positioning System
GSGF	Global Statistical Geospatial Framework
ICG	International Committee on GNSS
ICT	Information and Communications Technology
IDA	Initial Damage Assessment
IGIF	United Nations Integrated Geospatial Information Framework
IGMASS	International Global Aerospace System
InSAR	Interferometric Synthetic Aperture Radar
IoT	Internet of Things
IRENA	International Renewable Energy Agency
ISRO	Indian Space Research Organisation

JAXA	Japan Aerospace Exploration Agency
LBS	Location-based services
LEO	Low Earth Orbit
LGUs	Local Government Units
LiDAR	Light Detection and Ranging
MEO	Medium Earth Orbit
MGA	Multi-GNSS Asia
MODIS	Moderate Resolution Imaging Spectroradiometer
MORDI	Mainstreaming of Rural Development Innovation
NAP-DRR	National Strategic Action Plan for Disaster Risk Reduction
NASA	National Aeronautics and Space Administration
NDRMF	National Catastrophe Modelling Project for the National Disaster Risk Management Fund
NDVI	Normalized Difference Vegetation Index
NDWI	Normalized Difference Water Index
NEMO	National Emergency Management Office
NHs	National Highways
NRM	Natural Resource Management
NSDI	National Spatial Data Infrastructure
ODC	Open Data Cube
OECD	Organisation for Economic Cooperation and Development
OSM	OpenStreetMap
PMOC	Government Emergency Situation Analysis System
QR CODE	Quick Response code
QZSS	Quasi-Zenith Satellite System
RADI	Remote Sensing and Digital Earth
RAI	Rural Access Index
RDCYIS	Regional Drought and Crop Yield Information System
RESAP	Regional Space Applications Programme for Sustainable Development
RFSA or Roscosmos	Russian Federal Space Agency
RIMES	Regional Integrated Multi-Hazard Early Warning System for Africa and Asia
RSDP	Remote Sensing Data Policy
SAFE	Space Applications for Environment
SAR	Synthetic Aperture Radar
SDG	Sustainable Development Goals
SDI	Spatial Data Infrastructure
SFDRR	Sendai Framework for Disaster Risk Reduction
SIDS	Small Island Developing States
SMART	Spatial Monitoring and Reporting Tool
SPARRSO	Space Research and Remote Sensing Organization, Bangladesh
SPREP	Secretariat of the Pacific Regional Environment Programme
TVAR	Total Value at Risk
UAV	Unmanned Aerial Vehicle
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UN-GGIM	United Nations Global Geospatial Information Management
UNITAR	United Nations Institute for Training and Research
UNOOSA	United Nations Office for Outer Space Affairs
UNOSAT	United Nations Operational Satellite Applications Programme
UN-SPIDER	United Nations Platform for Space-based Information for Disaster Management and Emergency Response
USAID	United States Agency for International Development
VGI	Volunteered Geographical Information
VTMS	Vessel Traffic Management System
WFP	World Food Programme
WMO	World Meteorological Organization

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NAVIGATION GUIDE

This compendium is designed for the reader to interact and navigate to the sections and examples of interest. Not every reader will read the publication through, but regardless of what they do read, they should come away understanding the range of benefits geospatial information provides to the Asia- Pacific Member States. Therefore, this digital publication is easily searchable and highly linked for easy navigation.

How to navigate through this document:

- Use 'Control or Command (Mac) + F' to search for a key term (i.e. country, topic, keyword).
- Activate the Content List on this PDF document for better navigation through the different sections as you read.
- Use the table of contents to click on a section you want to read more about or use Figure or Table list to quickly find examples for specific countries or themes you are interested in reading about.
- Throughout the document, there are 'in text links' which link similar practices and examples. You can click on these to navigate to another relevant section.
- There are hyperlinks within some footnotes, these link directly to relevant internet web pages if you would like to explore further information.
- There is also an *Annex* at the end of this document with all of the country practices linked. You may use this to find examples for specific countries or thematic areas.

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Chapter 1.

Introduction

1. Geospatial information: An invaluable resource for the Asia-Pacific region

Geospatial information is data referenced to a location of geographical features on the Earth. This digital, location-based data creates a blueprint of what is happening when and where. From basic topographic features on a map to complex 3D models and images of natural phenomenon beyond what the human eye can see, space applications, comprising of geospatial information and remotely sensed data, provides far-reaching solutions to the pressing issues facing humanity. The development of space applications has accelerated in recent years and now contributes to several sectors. These range from health, in particular, the ongoing coronavirus disease (COVID-19) pandemic; education; food security; agriculture; energy; disaster risk reduction; and resilience-building. These applications are vital in our digital world, not only to everyday life, but as an important contributor to national development planning and decision-making.

Figure 1.1 **Heads of delegation of the Third Ministerial Conference on Space Applications for Sustainable Development in Asia and the Pacific, 2018**

Source: ESCAP Photo.

Today, geospatial information has expanded into almost every sector and more people around the world are realizing the potential that geospatial information and applications can provide. It has invaluable, invisible and incredible impacts on the life on and ecosystem of the Earth. The transformation of downstream space applications and the use of geospatial information are sparking innovations that attract both public and private capital. Capitalizing on digitalization and the progress of the Internet of Things (IoT), new start-ups continue to disrupt the market and add spillover benefits of space investments in research and development. For example, integrating geospatial data and existing statistics and ground-based information and exploiting new data sources, analytics, processes and tools has proven instrumental in delivering timely and authoritative information necessary for governments, businesses, communities and citizens to take action and make evidenced-based decisions. In addition, space-based technology applications, including satellite remote sensing, telecommunication, navigation and positioning enhances the data, tools and capabilities available. The ever-expanding variety, velocity, veracity and volume of data is being matched by infrastructure and technology that can curate, analyse and provide meaningful, evidence-based insights faster and with deeper rigour than ever before.

Rapid digital innovation continues to augment the availability of geospatial information, providing Asia-Pacific countries, particularly those with special needs, with an expanded choice of tools to implement the 2030 Agenda for Sustainable Development.[1] Despite advances in the availability and quality of geospatial information, several gaps and challenges remain for its effective use at the regional and national levels. This includes the availability of capacity and financial resources, the availability of space-derived data, the knowledge and expertise to use this data, and the availability of specific tools to translate the data into practical applications that can be used by decision makers who do not have a background in space applications. To help address these challenges, this publication aims to provide information and inspiration to countries to develop and manage their geospatial information resources, to integrate new and innovative approaches for evidence-based decision-making, and to highlight relevant country situations and circumstances. This document includes practical and actionable recommendations based on an analysis of technological and policy trends, emphasizing good practices from countries

[1] United Nations, Transforming our world: The 2030 Agenda for Sustainable Development (A/RES/70/1). Available at https://sustainabledevelopment.un.org/content/documents/21252030%20Agenda%20for%20Sustainable%20Development%20web.pdf

around the world with a focus on the Asia-Pacific region.

This knowledge sharing publication demonstrates the far-reaching potential benefits and applications geospatial information provides to Asian and Pacific countries. Examples from countries will illustrate the value of geospatial information across sectors and thus aim to reach, inform and inspire those policy and decision makers, officials and practitioners who are working towards evidence-based sustainable development in all sectors.

Asia-Pacific Plan of Action on Space Applications for Sustainable Development (2018–2030)

Countries within the Asia-Pacific region are already making steady progress on the uses of geospatial information and space applications. This has been demonstrated by the latest development of the *Asia-Pacific Plan of Action on Space Applications for Sustainable Development (2018–2030) (Plan of Action)*. This Plan of Action is a needs-driven blueprint that harnesses space and geospatial applications, as well as digital innovations to support countries, particularly those with special needs, to achieve the 2030 Agenda. The Economic and Social Commission for Asia and the Pacific (ESCAP), which serves as the United Nations' regional hub, promotes cooperation among countries to achieve inclusive and sustainable development, thereby becoming the first UN Regional Commission to adopt and implement a regionally-coordinated and inclusive action Plan of Action on space applications towards achieving the Sustainable Development Goals. Ministers and the heads of the space community from over 30 countries within the Asia-Pacific region met, in Bangkok, for the Third Ministerial Conference on Space Applications for Sustainable Development in Asia and the Pacific, in October 2018. The Ministerial Conference adopted two documents that will guide work in the Asia-Pacific region for the next decade: 1) the Ministerial Declaration on Space Applications for Sustainable Development in Asia and the Pacific, and 2) the Asia-Pacific Plan of Action on Space Applications for Sustainable Development (2018 – 2030).

Box 1 Geospatial information and space applications in daily life

Geospatial information and space applications provide powerful tools and frameworks for gathering, analysing and managing data. They play a large role in our daily lives and are deeply embedded in everyday activities. With technological advances, geospatial information and applications are now accessible on more devices, such as smart phones and smart watches. From the mapping application on smartphones to navigate to a new location or check the traffic, to checking the weather forecast for the day, people are tapping into the benefit of geospatial information and space applications. This includes mapping and monitoring the spread of disease and other outbreaks, environmental impacts, changes in land use, disaster management and response, and weather patterns and their effects on agriculture and livelihoods. Additionally, geospatial information and applications provide opportunities for enhanced engagement with citizens and improved accountability.

Many of these applications are reliant on space infrastructure set up by public and/or private actors and include services and products for consumers using satellite technology and capacity. This includes communications devices, satellite television services, Earth observation, meteorology and global and regionally enhanced location-based services. These local-based services, commonly known as Global Navigation Satellite System (GNSS), aid navigation devices using satellite positioning signals from publicly funded space infrastructure and have been rapidly expanding over time. These include many global and regional systems, such as the United States Global Positioning System (GPS), the European Galileo system, the Chinese Beidou systems, the Indian Regional Navigation Satellite System (NavIC) and the Japanese Quasi-Zenith Satellite System (QZSS), see examples in *Chapter 9*. The value creation and revenue generation from the ever-growing space economy and investment (both public and private) are often far removed from the initial investments, but without a doubt space-derived products, services and knowledge have widespread impacts on the economy and society.[a]

[a] Organization for Economic Cooperation and Development (OECD), The Space Economy in Figures: How Space Contributes to the Global Economy (Paris, 2019), p. 30. Available at https://doi.org/10.1787/c5996201-en

2. COVID-19: The important roles of geospatial information in a global pandemic

The coronavirus disease 2019 (COVID-19) has developed into a global pandemic that continues to take its toll across the world. This global crisis has and will continue to trigger tremendous social and economic impacts. In addition to the tragic loss of life, travel restrictions, lockdowns, and the suspension of production activities have disrupted labour markets and supply chains, resulting in increased unemployment and social instability. In order to save lives, protect people, and build back better, Member States, cities, and communities have incorporated geospatial information into their responses to the COVID-19 pandemic and its wake of socioeconomic impacts. In response to the COVID-19 outbreak and the economic and development crisis surrounding it, the ESCAP Secretariat developed a Framework, aligned with the global UN framework, which sets out ESCAP's offer and value addition to support Member States in their socioeconomic response to COVID-19, around three main streams of work: protecting people and enhancing resilience; supporting economic recovery; and restoring supply chains and supporting small and medium-sized enterprises.[2] The first two streams of work are particularly relevant to space technology applications and will be illustrated through country practices in *Chapter 6*.[3]

The Asia-Pacific Plan of Action on Space Applications for Sustainable Development (2018–2030), with much foresight, included epidemics in its proposed actions. It specifically requested ESCAP and its Member States to strengthen regional cooperation in order to: 1) leverage data sharing, and promote Big Data analytics for the containment of present and future spreads of diseases and epidemics, 2) to develop capacity on mapping health risk hotspots

[2] "Socio-economic response to COVID-19: ESCAP Framework". Available at https://www.unescap.org/sites/default/files/ESCAP%20COVID-19%20Framework%20Paper.pdf

[3] For more information, see examples on COVID-19 in the Health subsection in Chapter 6.

Box 2 The origin of Geographical Information Systems (GIS) as a public health tool

There is a natural link between geospatial information and epidemiology, not only for contact tracing, but also for many potential, though not immediately obvious, trends and risks that can help plan for and mitigate the socioeconomic impacts of epidemics. In the 1854 Broad Street cholera outbreak, Dr. John Snow demonstrated the waterborne origin of cholera by plotting cholera-related deaths and city water pumps in London on a map.[a] This early mapping technique identified the main water pump that spread the infection and illustrated the geospatial correlation between disease incidence and spread, sparking the beginnings of Geographic Information Systems (GIS). Since then, medical geography has transitioned from a largely descriptive science to an analytical science, thanks to increasingly sophisticated medical research, new scientific techniques, and rapid advancement in computer mapping technology.

Figure 1.2 Cholera map created by Dr. John Snow, 1854

Source: "Mapping a London epidemic", National Geographic Resource Library. Available at https://www.nationalgeographic.org/activity/mapping-london-epidemic/)

[a] George J. Musa and others, "Use of GIS mapping as a public health tool—from cholera to cancer", Health Services Insights, vol. 6 (2013), pp. 111–116.

using geospatial information and Big Data, and 3) to pay special attention to the countries that are most vulnerable to emergency health situations.

Geospatial information can strengthen the capacity of countries to detect, rapidly assess, monitor, and predict the spread of disease. As the COVID-19 pandemic progresses, governments around the world rely on measures such as contact tracing, quarantining, and social distancing. All of these are spatial in nature and rely on geospatial information. Indeed, people in vulnerable situations are at disparate risk to COVID-19 and can benefit from geospatial applications. For example, Indonesian authorities produced "heat maps", that pinpoint these vulnerable communities and at-risk populations.[4] The availability of such information allows countries to produce responses that are sensitive towards differences in vulnerability, through well-targeted policy-relief and efficient resource mobilization. Geospatial information also enables cross-cutting analysis and rapid impact assessment, which is essential for analysis of policy priorities, and can be clearly illustrated through geospatial dashboards like the one developed in Thailand,[5] to help policymakers prioritize actions and target areas necessary to contain the crisis and determine the impacts of the Government's response measures. Furthermore, ESCAP is now working in pilot areas with national partners to integrate geospatial and socioeconomic information and identify correlations between COVID-19 and "place, space and community" characteristics.

Additionally, geospatial information allows more accurate and efficient data communication and analysis to keep the public informed, which has helped decision-making and public response. Many countries in Asia and the Pacific have launched geo-enabled mobile applications to help with contact tracing and to determine hotspot areas. Empowered by accurate information and mapping techniques, the public can better understand the risks and spread of COVID-19 and make plans accordingly.

[4] For more information, see the Indonesia example in Chapter 6.

[5] For more information, see the Thailand COVID-19 Dashboard example in Chapter 6.

3. Space applications and the global sustainability agendas

With the adoption of the 2030 Agenda for Sustainable Development, the Sendai Framework for Disaster Risk Reduction (SFDRR), and the Paris Agreement in 2015, a new integrated global development agenda was set. Thus, the next 10 years to 2030 will be crucial in developing and delivering the Sustainable Development Goals (SDGs) and transforming the world for generations to come.[6] The UN Secretary General, António Guterres, stated that this is a decade of action, and we must address our 21st century challenges with 21st century solutions.[7]

The advancements in technology, geospatial information and applications now, more than ever, provide an immense opportunity for leaders of the space community. The UN Committee on the Peaceful Uses of Outer Space (COPUOS) has developed the Space 2030 agenda with Member States. This is a step change in how space can be considered in the UN system, with a vision to enhance space science and technology for the 2030 Agenda for Sustainable Development. The space sector, one of the most progressive fields today, will continue to develop and emerge as a critical player in addressing and resolving many collective development issues and challenges, namely in health, migration, urbanization, agriculture and sustainable food production, water management, emergency preparedness and disaster management, climate change, conflicts and protracted crises, frontier technologies, and international cooperation and interoperability.[8] Geospatial information and applications have a prominent role in the implementation, monitoring and realization of the 2030 Agenda for Sustainable Development.[9]

Although the Asia-Pacific region has made progress towards the SDGs, many countries within the region still struggle with persistent poverty and inequality, where 400 million people live in extreme poverty and 1.2 billion people live very close to the poverty line.[10] The Asia-Pacific region is also the most disaster-prone region in the world, with over 500 million poor people living in medium or high disaster risk. Additionally, Asia and the Pacific is also one of the most digitally divided regions in the world, where approximately half of the population has no access to the Internet and lower-income and geographically remote countries remain the most disconnected. These factors disrupt efforts to achieve the 2030 Agenda and at this stage no ESCAP Member States are on track to fully achieve the SDGs in the next decade.[11]

At the same time, technological and geospatial innovations in the region provide unprecedented opportunities to accelerate sustainable development, build resilience and deepen connectivity. Recognizing these opportunities, countries in Asia and the Pacific have developed the '*Regional Road Map for Implementing the 2030 Agenda for Sustainable Development in Asia and the Pacific*',[12] in order to facilitate cooperation at the regional level, which is supported by ESCAP and other UN entities. The road map calls on regional cooperation and has identified the major challenges still faced within the region. Alongside this, ESCAP, with help from Member States, has developed the 'Asia-Pacific Plan of Action on Space Applications for Sustainable Development (2018-2030)',[13] to facilitate cooperation on space related activities at the regional level. The Plan of Action maps the sectoral needs and resources at national and regional levels and promotes multi-sectoral coordination.

The Plan of Action is fully aligned with the ESCAP's 'Regional Roadmap for Implementing the 2030 Agenda for Sustainable Development in Asia and the Pacific'. It includes 188 actions in the following thematic areas: (a) disaster risk management; (b) natural resource management; (c) connectivity;

[6] United Nations, "Decade of Action". Available at https://www.un.org/sustainabledevelopment/decade-of-action/

[7] United Nations, "Remarks to the General Assembly on the Secretary-General's Priorities for 2020", speech, 22 January 2020. Available at https://www.un.org/sg/en/content/sg/speeches/2020-01-22/remarks-general-assembly-priorities-for-2020

[8] A/AC/105/1230; see United Nations General Assembly, Committee on the Peaceful Uses of Outer Space, Sixty-third session, Coordination of space-related activities within the United Nations system: directions and anticipated results for the period 2020-2021 – megatrends and the Sustainable Development Goals, Report of the Secretary-General, 2020.

[9] Asia-Pacific Plan of Action on Space Applications for Sustainable Development (2018–2030). Note by the Secretariat, seventy-fifth session, Bangkok, 27-31 May 2019 (ESCAP/75/10/Add.2).

[10] United Nations, Economic and Social Commission for Asia and the Pacific (ESCAP), Asian Development Bank and United Nations Development Programme, "Fast-tracking the SDGs: Driving Asia-Pacific Transformations", Bangkok, Thailand, 2020. Available at https://sdgasiapacific.net/sites/default/files/public/publications/resources/sdg-ap-kp-0000020-0005-en.pdf

[11] Asia and the Pacific SDG Progress Report 2020 (United Nations publication, Sales No. E.20.II.F.10). Available at https://www.unescap.org/publications/asia-and-pacific-sdg-progress-report-2020

[12] United Nations, Economic and Social Commission for Asia and the Pacific (ESCAP) "Regional Roadmap for Implementing the 2030 Agenda for Sustainable Development in Asia and the Pacific". Available at https://www.unescap.org/sites/default/files/publications/SDGs-Regional-Roadmap.pdf

[13] Asia-Pacific Plan of Action on Space Applications for Sustainable Development (2018-2030). Note by the Secretariat, seventy-fifth session, Bangkok, 27-31 May 2019 (ESCAP/75/10/Add.2). Available from: https://www.unescap.org/sites/default/files/MCSASD_2018_2E_Final_25102018.pdf

Figure 1.3 The six priority thematic areas of the Plan of Action that support the implementation of the Sustainable Development Goals and the Sendai Framework for Disaster Risk Reduction

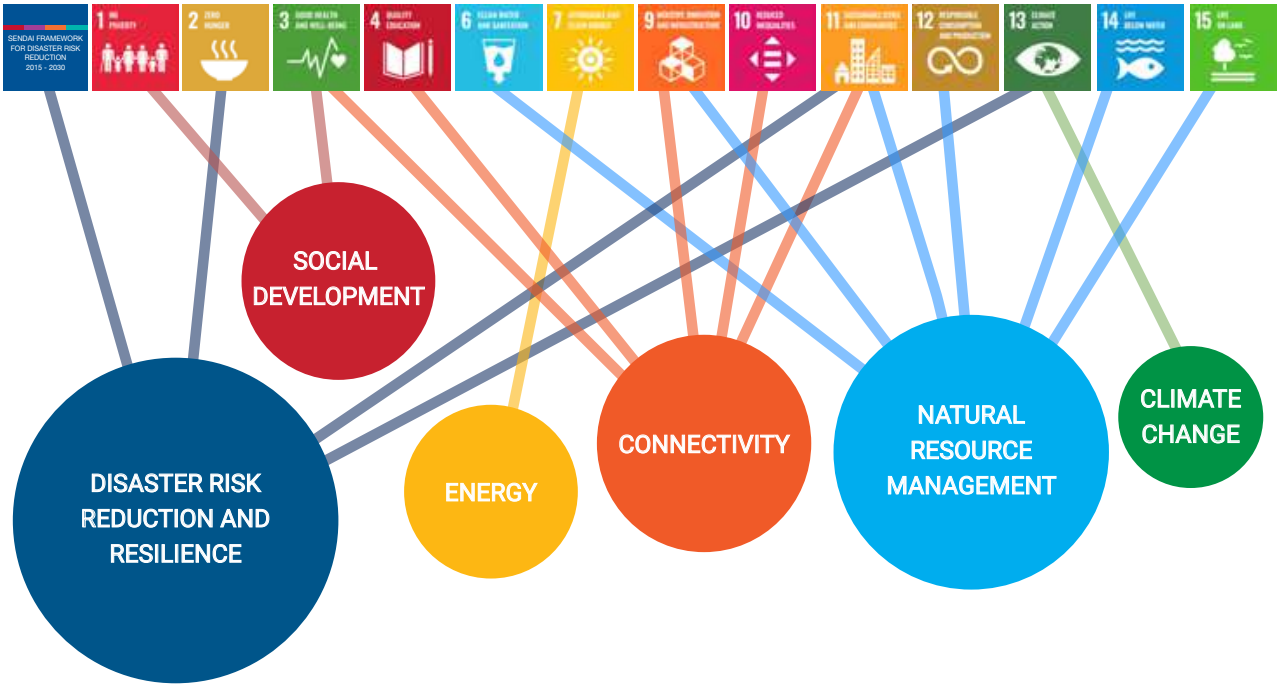
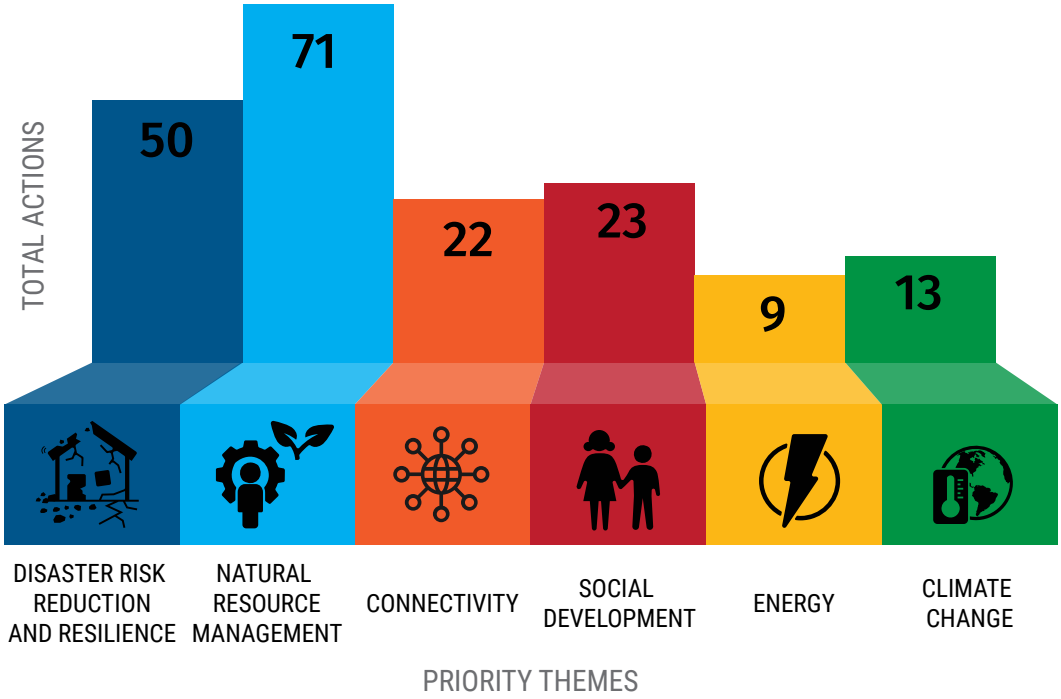


Figure 1.4 The total actions for the six priority areas in the Plan of Action



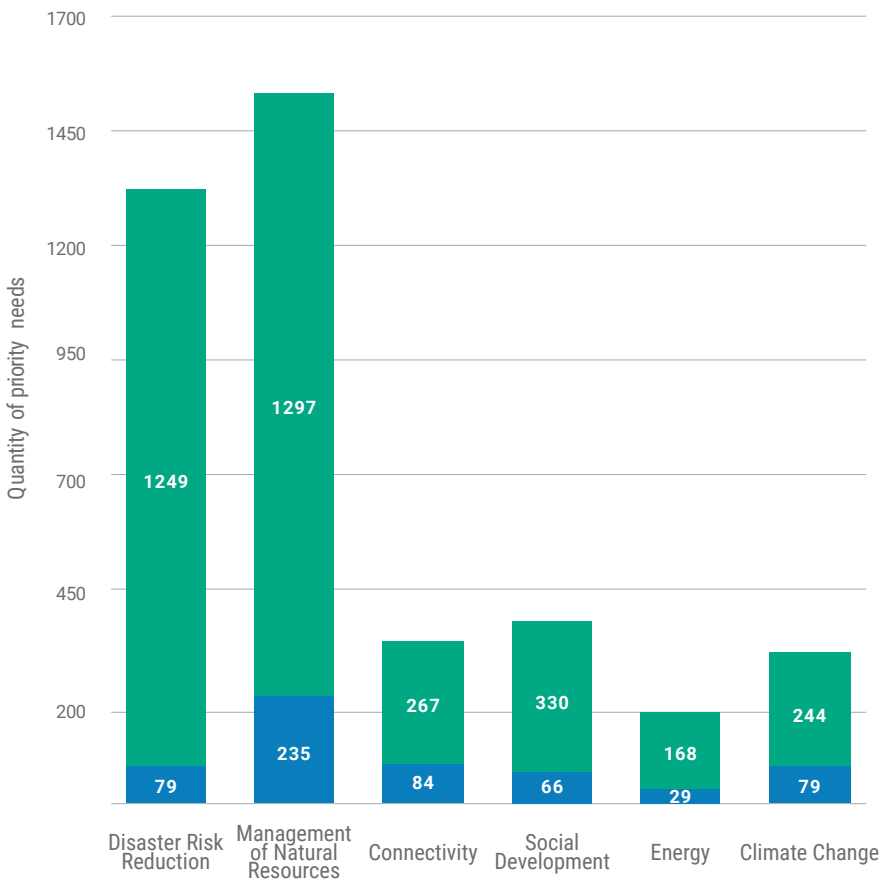
(d) social development; (e) energy; and (f) climate change. All actions will significantly contribute to the 37 Targets of the 14 Goals of the 2030 Agenda for Sustainable Development.

The implementation modalities are through: (a) research and knowledge-sharing; (b) capacity-building and technical support; and (c) intergovernmental discussions and regional practices. Among the three, capacity-building and technical support has been identified by countries as the priority in implementing the Plan of Action. The Plan is divided into three implementation phases, each of a four-year duration, with a Ministerial Conference to be convened at the end of each phase.

In late 2019, ESCAP, as the Secretariat of Regional Space Applications Programme for Sustainable Development (RESAP) which was established in 1994, undertook a detailed survey and analysis of the needs and contributions of various countries with respect to implementation of the Plan. Around 20 Member States and associate members of ESCAP responded with their needs relating to the 188 actions under the Plan of Action for its Phase I (2018-2022), and proposed contributions on how they can support other countries. Country responses included over 2,500 requests for assistance to meet specific priority needs related to natural resource management and disaster risk management. In addition, country responses included over 1,000 requests for assistance in the other thematic areas identified in the Plan. The Asia-Pacific region is fortunate to have some of the most advanced spacefaring countries which have offered to provide support for these needs in various ways, such as sharing knowledge and experience, and providing data, expertise and tools. In this regard, ESCAP is curating and sharing the country practices and recommendations in this publication and has begun to facilitate the bringing together of these countries to address the gaps and needs.

Countries within the region have been working towards implementation of these agendas by using geospatial information for sustainable development in various sectors. Countries contributed an array of over 100 examples from across many ministries on practical uses of geospatial information to support

Figure 1.5 The total priority needs matched to contributions by thematic area



sustainable development, under the Plan of Action for its Phase I (2018-2022). These include examples that are important and significant in each country's context based on local access and capacity to collect, use, and leverage geospatial information. Due to the diversity and disparities that exist across the vast extent of the Asia-Pacific region, the examples presented fall along a spectrum of sophistication and readiness level. This publication will explore these examples covering the six priority areas identified in the Regional Road Map and Plan of Action, demonstrating the progress already made by Member States and international organizations.

The publication will cover the following four areas:

1. *A regional status review of the context for space applications*;
2. *Space for socioeconomic development - Selected highlights from countries in the Asia-Pacific region organized by thematic areas*;
3. *Trends and innovative technologies*;
4. *Policy recommendations and key success factors related to the Asia-Pacific Plan of Action on Space Applications for Sustainable Development (2018-2030)*.

Table 1.1 Top 10 needs identified in the ESCAP needs and contributions survey, 2019. Priorities are health, urban development, and disaster risk reduction

Rank	Action Name	Thematic Area
1	Share good practices from the health sector, and work with existing intergovernmental mechanisms, international and regional organizations and relevant implementing agencies that could benefit from the use of geo-information science.	Social Development
2	Develop capacity for mapping and modelling urban and peri-urban areas and settlements.	Management of Natural Resources
3	Develop capacity to map health risk hotspots using geospatial information and Big Data.	Social Development
4	Develop capacity in integrating and utilizing space and geo-informatics applications with new methods, tools and technologies from other digital innovations, for the mapping process.	Disaster Risk Reduction
5	Research opportunities for including Global Satellite Navigation System for infrastructure and utilities mapping, that are relevant to disaster damage assessment and early warning systems.	Disaster Risk Reduction
6	Provide technical support on how to integrate, enhance and strengthen multi-hazard monitoring and early warning systems and real-time situational analysis for rapid-onset disasters, including flash floods from high-altitude lake and glacial outbursts, as well as slow-onset disasters, including drought and sand and dust storms.	Disaster Risk Reduction
7	Promote the use of geospatial information management systems, global navigation satellite systems and communications satellite systems towards disaster risk reduction and management at the policy level.	Disaster Risk Reduction
8	Identify interfaces between, and integration of, traditional space-based information and frontier technologies to address disaster risk management and build resilience.	Disaster Risk Reduction
9	Develop community-based hazard maps to raise awareness on preparedness and mitigation.	Social Development
10	Carry out risk mapping of highly vulnerable areas and communities by identifying hazards, vulnerabilities and exposure to risks.	Disaster Risk Reduction

Chapter 2.

Regional context for space applications

This chapter provides a brief background on the regional context for space applications in Asia and the Pacific. An overview of relevant global and regional policy and initiatives are explained, including those by the United Nations, international and regional institutions and other highlighted national space agencies and institutions.

1. An overview of space applications from a global and regional context

Interest in the space sector and its applications has never been greater; more than 4,500 satellites are in orbit, registered in more than 80 countries, with increasing public and private investments.[1] Since the launch of the first satellite in 1957, the United Nations has been working to ensure peaceful and safe uses of space science technology and exploration. Since then, space applications, such as geospatial information, Earth observation and

[1] United Nations, Office for Outer Space Affairs, "Outer Space Objects Index". Available at www.unoosa.org/oosa/osoindex/index.jspx?lf_id (accessed on 30 July 2020).

GNSS (Global Navigation Satellite Systems) have become more developed and are integrated into national development programmes, confirming the value of these applications. 50 years later, in 2019, the 74th United Nations General Assembly adopted a resolution reaffirming that space applications "provide indispensable tools for viable long-term solutions for sustainable development", and emphasized that regional and international cooperation, within the field of space activities, is essential in the development of space capabilities which will contribute toward the implementation of the 2030 Agenda.[2]

Regional Space Applications Programme for Sustainable Development in Asia and the Pacific

Through its long-standing Regional Space Applications Programme for Sustainable Development (RESAP), ESCAP has made concerted efforts to promote the application of space technology and Geographic Information Systems (GIS) for supporting disaster risk reduction and inclusive and sustainable development. For example, in times of disaster and emergency, and to avoid the loss of life and minimize economic losses, ESCAP responds promptly to requests for support by disaster affected Member States.[3] Furthermore, ESCAP gives high priority to capacity-building programmes and knowledge sharing, which are geared toward implementing the Asia-Pacific Plan of Action on Space Applications for Sustainable Development (2018 – 2030) (Plan of Action). For example, the initiative of "One Data-One Map-One Platform" is undertaken by the Secretariat to work with governments in order to build an innovative cloud system that utilizes frontier technologies, and integrates with big Earth Data to support monitoring and decision-making for the SDGs. Additionally, the "Space+" initiative goes beyond the traditional space applications approaches to support the implementation of the Plan of Action and will seek to: (a) leverage frontier technologies such as artificial intelligence, Internet of Things, cloud computing and Big Data; (b) engage end users in multiple areas, such as the youth or the private sector; (c) more effectively manage information through the creation of a regional or national cloud-based metadata platform; and (d) strengthen implementation through the creation of a trust fund and through enhanced partnership with global and regional stakeholders.

[2] United Nations, Office for Outer Space Affairs, "International cooperation in the peaceful uses of outer space". Seventy-fourth session, 2019. (A/RES/74/82).

[3] For more information, see *Section 3b*.

2. United Nations initiatives

The United Nations Committee of the Peaceful Uses of Outer Space (COPUOS)

As space technology, especially satellites, keeps advancing, it is essential that these services are managed with proper policies and legislation. The United Nations Committee of the Peaceful Uses of Outer Space (COPUOS),[4] formed in 1959, has played an important role, within the space sector, by developing space law and promoting strong international cooperation.

The United Nations Office for Outer Space Affairs (UNOOSA) serves as the secretariat for COPUOS, which promotes international cooperation in the peaceful uses of outer space and facilitates the use of space science and technology for sustainable development. The office disseminates space-related information to Member States, in order to help improve the use of space science and technology for development, particularly for developing countries. The UNOOSA office also manages the United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER),[5] established in 2006. This platform aims to provide all countries and relevant international and regional organizations with universal access to space-derived data, information and services to support the entire disaster management cycle, including disaster planning, risk reduction and emergency response.

As a blueprint towards Space 2030, UNISPACE+50 was held in 2018 to engage all key stakeholders in the space arena, including governmental and non-governmental actors, the commercial sector, the civil society, the young generation and the public at large, and to build synergies with the outcomes of the key UN Summits that were held in 2015.[6] Formulated by all Member States, including space-faring countries from Asia and the Pacific, the Space2030 Agenda was developed as a comprehensive and forward-looking strategy to reaffirm and strengthen the contribution of space activities and space tools in order to achieve global agendas.[7] The implementation plan was developed with objectives to build synergies and to engage all key stakeholders in the space area, enhancing space-derived economic benefits and strengthening the role of the space sector as a major driver of sustainable development. The Space2030 Agenda promises a change in how space is considered in the UN system, with Member States laying out a vision to enhance the use of space science and technology to work toward the 2030 Agenda for Sustainable Development.

The United Nations Global Geospatial Information Management (UN-GGIM)

The United Nations Global Geospatial Information Management(UN-GGIM),[8]istheapexintergovernmental mechanism for making joint decisions and setting directions regarding the production, availability and use of geospatial information within national, regional and global policy frameworks. Led by the Member States, UN-GGIM aims to address global challenges regarding the use of geospatial information, as included in the development agendas, and to serve as a global policymaking body in the field of geospatial information management. For example, UN-GGIM is advancing and securing the future role of geospatial information and Earth observations to support the implementation of the SDGs through the *United Nations Integrated Geospatial Information Framework (IGIF)*.[9]

UN-GGIM-AP

The Regional Committee of the United Nations Global Geospatial Information Management for Asia and the Pacific (UN-GGIM-AP)[10] brings Member States together to exchange and promote the use of geospatial information in order to identify problems and find solutions regarding the overarching goal of sustainable development of the countries. ESCAP serves as the Secretariat of UN-GGIM-AP. The aim of UN-GGIM-AP is to identify regional issues relevant to geospatial information management, to take necessary actions on them and to maximize economic, social and environmental benefits of geospatial information in Asia and the Pacific. UN-GGIM-AP seeks to further discussions between countries to find solutions and even contributes toward discussions on a global level.

[4] United Nations, Office for Outer Space Affairs, "Committee on the Peaceful Uses of Outer Space", 2020. Available at https://www.unoosa.org/oosa/en/ourwork/copuos/index.html

[5] United Nations Platform for Space-based Information for Disaster Management and Emergency Response, Available at https://un-spider.org/

[6] "UNISPACE+50". Available at: http://www.unoosa.org/documents/pdf/unispace/plus50/UNISPACE50_Overview.pdf

[7] United Nations, Office for Outer Space Affairs, "Revised zero draft of the "Space 2030" Agenda and implementation plan", 2019. (A/AC.105/2019/CRP.15).

[8] United Nations, Department of Economic and Social Affairs, Statistics Division, "UN-GGIM". Available at https://ggim.un.org/

[9] For more information on IGIF, see section 3.c in Chapter 9.

[10] United Nations, "Regional Committee of United Nations Global Geospatial Information Management for Asia and the Pacific". Eighth Plenary Meeting of UN-GGIM-AP, 2019. Available at https://www.un-ggim-ap.org/

UN-GGIM-AP established three working groups on the topics identified by the Member States:

1) Geodetic Reference Frame, 2) Cadastre and Land Management and 3) Integrating Geospatial Information and Statistics.

The United Nations Operational Satellite Applications Programme (UNOSAT)[11]

In 2001, the United Nations Operational Satellite Applications Programme (UNOSAT) was established as an operational technology-intensive programme of the United Nations Institute for Training and Research (UNITAR). Today, UNOSAT is a thriving centre which provides timely and high-quality geospatial information, through GIS and satellite imagery, to United Nations' decision makers, Member States, international organizations and non-government organizations. UNOSAT develops and deploys solutions through remote sensing imagery and GIS data via web-mapping and information sharing mechanisms. UNOSAT has provided space products to multiple countries in need during humanitarian relief and coordination, such as crisis situations, damage and impact mapping, human security and humanitarian law and territorial planning and mapping. In the Asia-Pacific region, ESCAP hosts and closely collaborates with the UNITAR-UNOSAT Centre in Bangkok.

Through these mechanisms, the United Nations is working towards improved international cooperation in the field of space applications, in order to bring space technology uses to all nations.

3. International and regional initiatives

Group on Earth Observation (GEO)

With a partnership of more than 100 governments and more than 100 participating organizations, the GEO aims to combine, for all its members, the monitoring capabilities to assist decision makers with Earth observation data for sustainable development.[12] In effect, GEO connects those in need of information and those who collect information so as to maximize the benefits of Earth observation data and knowledge.[13] The community of GEO is developing the Global Earth Observation Systems of Systems (GEOSS) for integration of Earth observing systems and existing data structures. As a standardized processing system, GEOSS is open to public and private sector users so they can access and use a diverse set of Earth observation information.[14] Amongst this massive network is the Asia-Oceania GEOSS. The Asia-Oceania Group on Earth Observations (AOGEO) consists of 22 GEO Asia-Oceania Caucus Member States and works across twelve task groups that align with the region's development needs.[15]

Regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES)[16]

Established through the ESCAP Trust Fund for Tsunami, Disaster and Climate Preparedness, RIMES is a regional project for sustaining the early warning system for natural hazards. Since its formal institution in 2009, RIMES has developed a portfolio of services and tools that assimilate information on a real-time basis and dynamically render risk scenarios to support planning and decision-making processes. RIMES utilizes innovative technologies including, analytics for producing informative data, machine learning algorithms to automate impact-based decision-making, and next-generation data processing and visualization platform, that are all integrated using open-source and free software utility packages. RIMES' tools utilize user feedback to remain relevant and are scalable to incorporate new technologies and requirements and better data/information as they become available. Countries can leverage RIMES institutional mechanisms in developing impact forecasting services and risk-based early warning systems.

The Framework for Resilient Development in the Pacific (FRDP)

The FRDP is an integrated approach to address climate change and disaster risk management, which was endorsed by the Pacific Island Forum Leaders, in 2016. The Framework seeks for Pacific countries to reduce their exposure to climate and disaster risk, improve disaster response and reconstruction, while supporting low carbon development.[17] Five technical working groups focus on key or emerging priorities, namely risk governance, disaster risk financing,

[11] United Nations Operational Satellite Applications Programme, Available at: https://unitar.org/sustainable-development-goals/satellite-analysis-and-applied-research

[12] Group on Earth Observations. Available at https://www.earthobservations.org/geo_community.php

[13] Group on Earth Observations, "GEO Strategic Plan 2016-2025: Implementing GEOSS". Available at https://www.earthobservations.org/documents/GEO_Strategic_Plan_2016_2025_Implementing_GEOSS.pdf

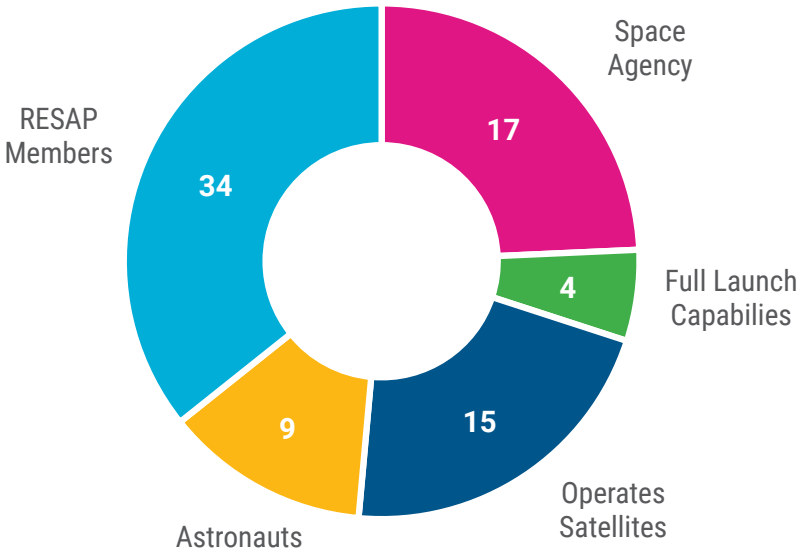
[14] Ibid.

[15] For example of GEO member work, see example in Chapter 8 3.a on a. China: TanSat mission to promote global carbon monitoring; for information on Asia-Oceania Group on Earth Observations (AOGEO), see https://aogeo.net/en/

[16] Regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES), "History". Available at http://www.rimes.int/?q=history

[17] Pacific Resilience Partnership. Available at http://www.resilientpacific.org/

Figure 2.1 The relative number of countries in Asia and the Pacific part of ESCAP's Regional Space Applications Programme for Sustainable Development, with full launch capabilities, space agencies, and countries that are somewhat active in space and GIS



human mobility, localization and information and knowledge management. Through the framework, information and reports relating to the COVID-19 crisis have also been released to aid Pacific Island senior leadership, policymakers and security officials in situational awareness for operational decision-making.[18]

International Committee on GNSS (ICG) and Multi-GNSS Asia (MGA)

The International Committee on GNSS (ICG)[19] promotes interoperability and compatibility among global and regional systems in order to maximize user benefits and facilitate developing countries in realizing the SDGs more effectively. For example, Japan continues to support international outreach activities on GNSS through MGA, an international organization endorsed by the International Committee on GNSS (ICG), which promotes multi GNSS in the Asia and Oceania regions, and encourages GNSS service providers and user communities to develop new applications and business. The MGA hosts an Annual conference, webinars, regional workshops and seminars as well as the MGA Students & Young Professionals Forum. The forum provides hands-on Hackathons, titled as the 'Rapid Prototype Development Challenge' where teams create prototypes using limited resources with the help of experts from the industry.

[18] Pacific Resilience Partnership, "Info on Covid 19". Available at http://www.resilientpacific.org/covid-19/

[19] UNOOSAT, The International Committee on GNSS (ICG), Available at: https://www.unoosa.org/oosa/en/ourwork/icg/annual-meetings.html

Additional organizations and actors, many of whom will be featured in the country practices in *Chapter 3*, include, but are not limited to: Asian Disaster Preparedness Center (ADPC),[20] Asia-Pacific Regional Space Agency Forum (APRSAF),[21] Sentinel Asia,[22] ASEAN Research Training Center for Space Technology and Applications (ARTSA),[23] Asia-Pacific Space Cooperation Organization (APSCO),[24] and the Centre for Space Science and Technology Education in the Asia and Pacific (CSSTEAP).[25]

4. Initiatives by national space agencies and other institutions in the Asia-Pacific region

Countries with space programmes and activities in the Asia-Pacific region have followed the global trend by moving from being a limited to a very exclusive club, to a much wider group of developed and developing countries with diverse capabilities

[20] Asian Disaster Preparedness Center (ADPC). Available at https://www.adpc.net/igo/?

[21] Asia-Pacific Regional Space Agency Forum (APRSAF). Available at https://www.aprsaf.org/

[22] Sentinel Asia. Available at https://sentinel-asia.org/

[23] ASEAN Research and Training Center for Space Technology and Applications (ARTSA). Available at http://artsa.gistda.or.th/

[24] Asia-Pacific Space Cooperation Organization (APSCO) Available at http://www.apsco.int/html/comp1/channel/aboutus/24.shtml

[25] Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP). Available at https://www.cssteap.org/

and applications.[26] As of June 2020, countries in the Asia-Pacific region with space agencies or same functions include: Australia, Azerbaijan, Bangladesh, China, India, Indonesia, the Islamic Republic of Iran, Japan, Malaysia, New Zealand, Philippines, the Republic of Kazakhstan, the Republic of Korea, the Russian Federation, Thailand, Turkmenistan, and the Republic of Uzbekistan. With a long-standing history of international cooperation, these space agencies play large roles both globally and in their respective national space industries. Over the past decades, international cooperation among space agencies has been strengthened through collaborative partnerships and projects. There includes increased participation and cooperation between these space agencies and those countries that do not have dedicated space agencies.

Many countries in the region, though not included in this list of space agencies, do have institutions active in leveraging geospatial and space applications, often including national space councils, relevant research institutes, academies, or ministries (often under Ministries of Science, Technology, and Information). These institutions play an important role in advocating for, developing, and implementing relevant plans, strategies and policies at the national level.

[26] Organization for Economic Cooperation and Development (OECD), The Space Economy in Figures: How Space Contributes to the Global Economy (Paris, OECD Publishing, 2019). Available at https://doi.org/10.1787/c5996201-en

Table 2.1 Selection of national strategies, policies and plans relevant to geospatial information in the Asia-Pacific region

Year	Country	Plan, Policy, Strategy
2005	Indonesia	Long-Term National Development Plan of 2005-2025
2005	Republic of Kazakhstan	Establishment of the Kazcosmos national state company (now - Gharysh Sapary)
2006	Viet Nam	Strategy for Research and Application of Space Technology of Vietnam until 2020
2010	Azerbaijan	Presidential Decree ref. 855 (establishing Azercosmos Open Joint-Stock Company)
2011	India	Remote Sensing Data Policy (RSDP)
2012	Republic of Kazakhstan	Law of the Republic of Kazakhstan on Space Activities
2012	The Russian Federation	GLONASS Sustainment, Development and Use for 2012-2020
2015	The Russian Federation	Law "On Space Activity" and law "On the State Corporation for Space Activities ROSCOSMOS"
2016	Indonesia	The One Map Policy
2016	China	13th Five-year Plan (2016-2020)
2016	Mongolia	Phase 2 of Millennium Development Goals (MDGs)-based Comprehensive National Development Strategy
2017	Japan	The Space Industry Vision 2030
2017	Malaysia	National Space Policy 2030
2017	Thailand	20-Year National Strategy (2018-2037)
2017	The Russian Federation	Federal Targeted Programme on the Development of Space Ports for 2017-2025
2017	New Zealand	Outer Space and High-altitude Activities Act 2017
2018	Singapore	Singapore Geospatial Master Plan

Year	Country	Plan, Policy, Strategy
2019	Australia	2019-20 Corporate Plan of Geoscience
2019	Nepal	15th Five Year Development Plan (2019/20-2023/24)
2019	Republic of Uzbekistan	Decree "On the Development of Space Activities in the Republic of Uzbekistan"
2019	Cambodia	National Strategic Action Plan for Disaster Risk Reduction (NAP-DRR) for 2019-2023
2019	Philippines	Philippine Space Act (Republic Act No. 11363)
2019	Republic of Uzbekistan	Measures related to the organization of The Space Research and Technology Agency under the Cabinet of Ministers of the Republic of Uzbekistan
2020	Armenia	Law on Space Activities

Furthermore, the Asia-Pacific region hosts a dynamic group of organizations and actors who play an important role in enhancing collaboration, sharing new advances, and leveraging geospatial information for development.

Research institutions and universities:

Universities and research institutions in the Asia-Pacific region are key players and leaders in research and innovation on space applications, playing an important role in training the next generation for utilizing geospatial information. As the geospatial field incorporates a mix of geography and computer science, the region hosts top universities in both fields with solid research experience in the region. Many universities are pioneering innovation in space applications, such as leveraging Artificial Intelligence (AI), Big Data and IoT.[27] Additionally, universities are a key entry point for engaging youth and inspiring innovation, especially within the space and geospatial application sector. A few selected examples from research institutes, within the Asia-Pacific region, are highlighted below.

- ESCAP sponsored youth participation in various courses, which includes four young professionals from Thailand, Cambodia, the Lao People's Democratic Republic and Myanmar to participate in the one-year Master's degree jointly organized with the ASEAN Research and Training Center for Space Technology and Applications and ARTSA, and five students from developing countries to undertake Master's studies at CSSTEAP, in India, in mid-2019. Students completing these programmes have developed their technical geospatial skills and learned innovative application of technologies which they can apply in designing specific space technology applications that support their country's needs in achieving the SDGs.
- With the support of India, ESCAP regularly facilitates young professional officials from developing countries in the region to join a nine month post-graduate course on remote sensing and the Global Navigation Satellite Systems at the Centre for Space Science and Technology Education in Asia Pacific, in Dehradun, India.[28]
- Australia and New Zealand host a range of universities offering geospatial, geoinformatics and geography courses. The Royal Melbourne Institute of Technology geospatial sciences team is the largest academic group of its kind in Australia, along with the University of Queensland which also covers a large range of

Figure 2.2 Institutional training at the Asian Institute of Technology, Thailand

Source: Geoinformatics Center, AIT.

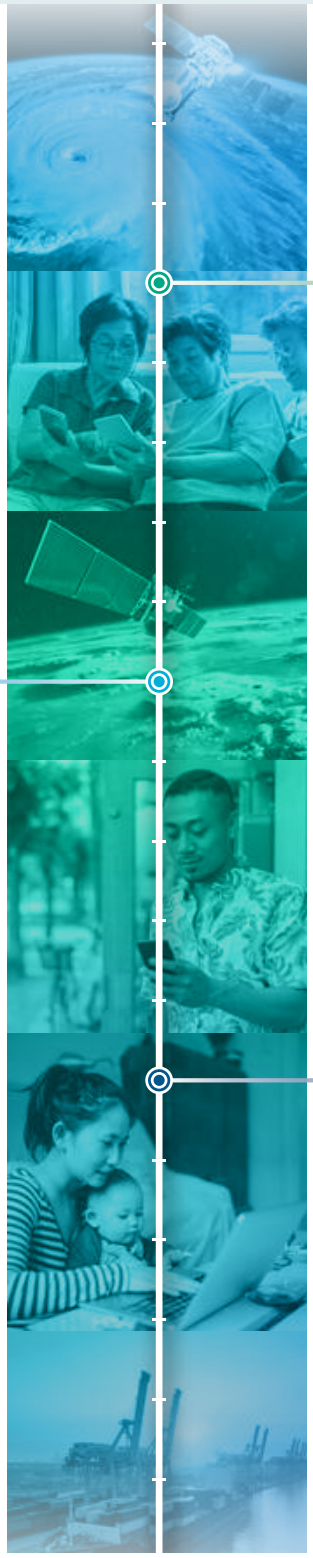
[27] For more information, see examples from universities and emerging trends section in Chapter 9.

[28] Centre for Space Science and Technology Education in Asia and the Pacific (CSSTEAP). Available at https://www.cssteap.org/

The following timeline displays a selection of recent highlights that contributed toward implementing the Plan of Action, beginning in 2018. It helps paint a picture of the recent evolution of space applications and the potential for leveraging these applications in the Asia-Pacific region.

The Plan of Action **HIGHLIGHTS**

On the path towards implementing the Asia-Pacific Plan of Action on Space Applications for Sustainable Development (2018–2030)



2018

- Bangabandhu Satellite-1, the first Bangladeshi geostationary communications and Broadcasting Satellite, launched
- Singapore Geospatial Master Plan approved
- Australian Space Agency formed
- Azerbaijan's the Azerspace-2 geostationary telecommunication satellite launched

2019

- First Thai space week held
- Malaysian Space Agency formed
- Philippines Space Act launched
- Sri Lanka's first nanosatellite launched
- Uzbekistan Space Agency, Uzbekspace, formed
- Japan National Space Policy Secretariat expands S-Booster

2020

- The Geostationary Environment Monitoring Spectrometer (GEMS) instrument launched on the Korean Aerospace Research Institute's GEO-KOMPSAT-2B satellite
- Bhutan space week held
- Geospatial applications to help tackle COVID-19 pandemic
- China's Beidou constellation is fully deployed to provide navigation services globally
- Indian National Space Promotion and Authorisation Centre (IN-SPACe) created to foster interlinkages between the government, academia and private space-related enterprises
- The Centre for Space Science and Technology Education in Asia Pacific (CSSTEAP) has trained 2394 students from 56 countries over the past 25 years
- Philippines Space Agency established

technical geospatial disciplines and hosts both the Remote Sensing Research Centre and Earth Observation Australia. These universities host a range of both domestic and international students, acting as hubs for international innovation and collaboration.

- The Department of Geography at the National University of Singapore, is ranked among the world's top 10 departments and includes key areas of geospatial science taught through numerous undergraduate, postgraduate and research courses.
- The Chinese University of Hong Kong in Hong Kong, China, also has a strong geospatial department, providing hands on experience for students to advance their GIS skills and research.[29]
- The Department of Geography at the University of Hong Kong, in Hong Kong, China, utilizes both traditional and innovative geospatial technologies to boost environmental conservation and *sustainable development* from regional to global scales management.[30] The Environment Research Group collects and integrates multisectoral geospatial data through GIS, Big Data analytics, data mining and AI. The main research foci are on the patterns and dynamics of climate, water, forests and air quality, thereby outlining adaptation and mitigation measures for effective conservation.
- The Asian Institute of Technology (AIT), in Thailand, has a strong Remote Sensing and GIS department which offers Masters and Doctorate studies. Students are exposed to advanced concepts of geospatial science, including advanced mapping technologies, synthetics aperture radar, sensor networks and geospatial Big Data.[31] AIT also hosts the Geoinformatics Center, a leading remote sensing and GIS research organization in South-East Asia. The centre recognizes the importance of emerging spatial technologies and assists in international projects and capacity development.[32]
- The University of Tokyo in Japan, also has established the Centre for Spatial Information Science as an internal joint-use facility by the university.[33] The centre has worked with a number of researchers within the university, along with the private sector and national institutions to build, develop and spread spatial information science.

The private sector:

The key actors in the private sector, in the region, range from the global giants like Google, ESRI (ArcGIS), and telecommunications companies to the small start-ups and host of entrepreneurs developing *digital innovations*, *platforms and tools*.[34] The COVID-19 pandemic highlights the importance of partnership between the public and private sector to leverage all the available space applications to tackle the pandemic and its cascade of impacts, such as the *partnership* amongst governments and Alipay, WeChat, and credit card companies for tracing and tracking.[35] Many regional and country-based efforts, such as incubators and competitions, support the start-ups and spinoffs from space applications research and pilots. Some of these include:

- The Funding Assistance for Spinoff and Translation of Research in Advancing Commercialization (FASTRAC) of the Department of Science and Technology in the Philippines support scaling up research and pilots such as the *CATCH-ALL traffic management system* set to be commercialized and adopted by local governments.[36, 37]
- The National Space Policy Secretariat, Cabinet Office of the Government of JAPAN has organized the regional S-Booster competition since 2016, to build a place where companies, individuals and organizations can gather to create new companies and services with "Space" assets. Through mentoring by space business experts, the selected entrants receive support in learning to commercialize an idea and to capitalize it. S-Booster finalists present their own business ideas directly to investors and business companies who are keen to support great space projects, and potential commercialization of the ideas.

[29] Geography Resource Management, "Geo-Spatial Data Science". Available at https://www.grm.cuhk.edu.hk/eng/prog/_geotech.html

[30] See more information on University of Hong Kong traffic control example in Chapter 5

[31] Remote Sensing and GIS (RS&GIS). Available at https://rsgis.ait.ac.th/main/about/

[32] Asian Institute of Technology, Geoinformatics Center. Available at http://geoinfo.ait.ac.th/about-us/about-gic/

[33] Center for Spatial Information Science (CSIS), The University of Tokyo. "What is Spatial Information Science?" Available at http://www.csis.u-tokyo.ac.jp/english/introduction.html

[34] For examples see COVID-19 section in Chapter 6 and Transport Management and Traffic Navigation section in Chapter 5.

[35] See China health QR codes section in Chapter 6.

[36] Republic of the Philippines, Philippine Council for Industry, Energy and Emerging Technology Research and Development (DOST-PCIEERD), Department of Science and Technology, "DOST PCIEERD strengthens technology transfer and commercialization efforts through its FASTRAC program", 10 December, 2020. Available at http://pcieerd.dost.gov.ph/news/latest-news/360-dost-pcieerd-strengthens-technology-transfer-and-commercialization-efforts-through-its-fastrac-program#:~:text=The%20FASTRAC%20or%20Funding%20Assistance,outputs%20into%20market%20ready%20products (accessed 30 July 2020).

[37] See CATCH-ALL example in Transport Management and Traffic Navigation section in Chapter 5.

Chapter 3.

Space for socioeconomic development - Highlights for disaster risk reduction and resilience

1. The Plan of Action as an organizing framework for Chapters 3-8

Over the past several years, the world has witnessed progress in access to space-generated technologies and information as a result of an exponential growth in Earth observation technologies, increasingly free access to satellite-derived data and enhanced information-sharing through regional cooperation. Several regional mechanisms have allowed policymakers, practitioners and scientists across the region to use and leverage satellite-derived information, without needing a space programme of their own.[1]

Amidst these developments, Asia and the Pacific has become a hub of digital and science innovation

[1] United Nations, Economic and Social Commission for Asia and the Pacific, "Towards a new Asia-Pacific strategy for using space applications to support the 2030 Agenda for Sustainable Development: an opportunity for the space community to shape a sustainable future", Working Paper, The 20th Session of the Intergovernmental Consultative Committee on the Regional Space Applications Programme for Sustainable Development for Asia and the Pacific and the Asia-Pacific Space Leaders Forum, New Delhi, 31 October to 2 November, 2016.

that brings new and innovative solutions to pressing global challenges. Faster and more versatile digital connectivity, satellite-derived data, geographic information systems (GIS), and spatial analysis has become increasingly accessible and available, generating more evidence-based data and approaches to support real-time decision-making.[2] Geospatial information has also increasingly been incorporated into national and local development planning, which has led to a more targeted use of resources and accurate monitoring and evaluation of interventions and programmes. As a result, geospatial information applications have come to play a more prominent role in the implementation of the 2030 Agenda for Sustainable Development, the Sendai Framework for Disaster Risk Reduction (SFDRR), and the Paris Agreement to strengthen the global response to the threat of climate change.

Countries in the region have been working towards the implementation of these agendas by using space applications and geospatial information for sustainable development across various sectors. This has demonstrated the diverse use for geospatial information and applications and the vital role that space applications will continue to play in the future. Countries from across the Asia-Pacific region were surveyed by ESCAP and contributed to an array of over a hundred examples, across many ministries, on the practical uses of geospatial information to support sustainable development as part of the first phase of implementing the Asia-Pacific Plan of Action on Space Applications for Sustainable Development (2018-2030) (Plan of Action). These include examples that are significant in each country's context, based on local access and their capacity to collect, use, and leverage geospatial information. Due to the diversity and disparities that exist across the vast extent of the Asia-Pacific region, the examples presented in this publication fall along a spectrum of sophistication and readiness level. In some country contexts, the highlight of the example includes an improvement in capability and steps taken toward fully leveraging geospatial information for development. The examples are not exhaustive, but do reflect the trends and status of the diverse use of space applications in the region.

However, despite the advances in digital connectivity, satellite data, GIS, and spatial analysis as mentioned above, several challenges remain. A lack of capacity and resources in terms of finance and expertise, is a common problem. Many developing countries, particularly the Small Island Developing States (SIDS), do not have the capacity to utilize, analyse and interpret space-derived data. The following chapters highlight operational experiences from over 20 countries despite limitations and challenges.

To address these challenges the inclusive and needs-driven Plan of Action provides a blueprint to harness space and geospatial applications, as well as digital innovations to support countries, particularly those with special needs, in order to achieve the 2030 Agenda.[3] Through the long-standing framework of the Regional Space Applications Programme for Sustainable Development (RESAP), ESCAP has brought together space agencies and relevant stakeholders to address development challenges. ESCAP will continue to facilitate research and knowledge-sharing, capacity-building and technical support, intergovernmental discussions and regional practices, and provide platforms, such as this publication, to collect, share, and promote good

[2] Asia-Pacific Plan of Action on Space Applications for Sustainable Development (2018-2030). Note by the Secretariat, seventy-fifth session, Bangkok, 27-31 May 2019 (ESCAP/75/10/Add.2).

[3] Ibid.

Chapter	Symbol	Theme
Chapter 3		Disaster Risk Reduction and Resilience
Chapter 4		Natural Resource Management
Chapter 5		Connectivity
Chapter 6		Social Development
Chapter 7		Energy
Chapter 8		Climate Change

practices and experience on space policies and legislation and raise awareness of the benefits and barriers to accessing space applications.

The following chapters will explore examples from countries in Asia and the Pacific, organized by the six priority areas identified in the Regional Road Map and Plan of Action.

Additionally, each country practices in Chapters 3-8 will include the relevant icons from the 34 subthemes of the Plan of Action (Table 3.1). This provides a visual illustration of how the wide range of examples are a path toward the implementation of the priority areas of the Plan of Action. Furthermore, these will highlight the cross-cutting and interdisciplinary nature of the country practices.

These chapters will explore the ways in which countries are using geospatial information for sustainable development with a focus on how the poorest, most vulnerable, and fragile ecosystems are helped using space-based data. These include a review of over a hundred practices contributed by countries and organizations in the region, their integration into management decisions, planning and policy, and lessons learned through highlighting the benefits provided to many sectors. The cases were provided by countries and directly involved stakeholders, and do not comprise the totality of relevant practices in the region. This compendium endeavours to highlight a diversity of approaches through sub-regional representation, and dive deeper into understanding the processes and enabling conditions for the case studies. Geospatial technologies and their applications are rapidly evolving and we aim to capture the most current status and analyse the latest trends.

2. Highlights in Asia and the Pacific for disaster risk reduction and resilience

The Asia-Pacific region is the most disaster-prone region in the world, with many vulnerable countries facing the brunt of increased natural catastrophes. Geospatial information has been widely recognized as an important aspect of disaster risk management. The availability and accessibility of quality geospatial data and information from authoritative sources ensure that decision makers and other concerned stakeholders have an accurate common operational picture of critical scenarios before, during and after disasters.[4] Due to the diversity of roles that geospatial information plays, it can be utilized for the whole disaster risk management cycle from preparedness, pre-disaster capacity-building, through to post-disaster relief and response.

Given the inter-regional nature of natural disasters, the Sustainable Development Goals (SDGs) and the SFDRR have both highlighted the urgent need for countries to work together to increase regional cooperation in disaster management. The SFDRR highlights, at the global, regional and national levels, the use of space applications, including geographic information systems and geospatial information technology, to enhance measurement tools, data collection, data analysis and dissemination of data. These actions will contribute to the implementation of multiple SDGs listed here and the SFDRR, which sets global common standards and targets for disaster risk reduction and has important synergies and common indicators with the three SDGs (Goal 2, Goal 11 and Goal 13). To achieve the reduction of disaster risks, it is also important to promote and enhance geospatial and space-based technologies through international cooperation.[5]

[4] United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM), "Strategic Framework on Geospatial Information and Services for Disasters: Preamble 2", Working group on Geospatial Information and Services for Disasters (WG-GISD), August 2017.

[5] United Nations Office for Disaster Risk Reduction, "Sendai Framework for Disaster Risk Reduction 2015 – 2030", 24(c), 24(f), 25(c), 25(g). Available at https://www.preventionweb.net/files/43291_sendaiframeworkfordrren.pdf

Table 3.1 Subtheme icon key

Disaster Risk Reduction and Resilience		
Innovation	Emergency Response	Precision Agriculture
Risk Reduction	Food Production	Climate Hazard
Disaster Assessment	Agroecosystem Resilience	

Natural Resource Management		
Water Quality, Water Resource Management	Consumption and Production	Water Pollution
Infrastructure	Forests	Marine Ecosystems
Cultural Heritage	Land Use Change	Costal Ecosystems
Waste Management	Biodiversity and Endangered Species	Sustainable Fisheries
Urban Planning	Land Degradation and Desertification	

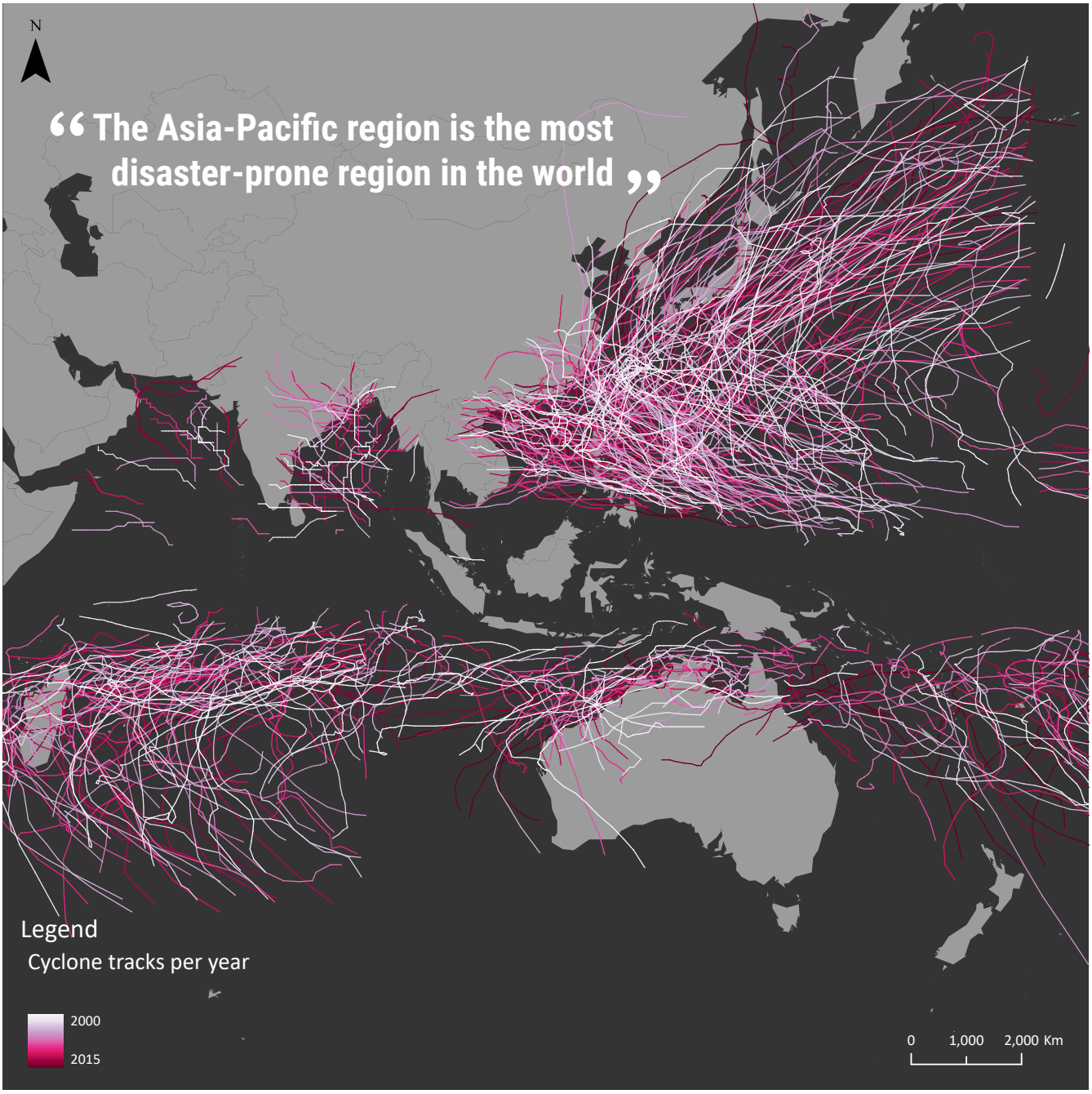
Connectivity		
Road Traffic Incidents	Access to the Internet	Transport Systems
Scholarships	Migration	

Social Development		
Poverty	Health Management	Contamination and Pollution
Vulnerable Groups		

Energy	Climate Change
Modern and Sustainable Energy Sources	Mitigation and Adaptation

Progress within the area of disaster risk reduction and resilience is ongoing and many countries within the region have made progress toward implementing strategies toward disaster management. This section highlights country practices and experiences within the disaster management sphere, with a focus on disaster assessment, emergency response, and agroecosystem resilience.

Cyclone track locations in the Asia-Pacific region, between 2000 and 2015



Map developed by ESCAP. Data Source: UNDRR, 2015.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

3. Innovation in disaster preparedness and management

To reduce disaster risk and build greater resiliency among communities and regions, the Plan of Action seeks to strengthen the integration of digital innovation with space applications for disaster risk reduction, multi-hazard monitoring and early warning, damage assessment and emergency response and recovery. Digital innovations are rapidly advancing, making room for more sophisticated technologies to play a role in the disaster cycle. Space-derived information and frontier technologies are being used in innovative ways to address disaster risk management and resilience. The following examples show how countries, from around the region, have leveraged innovative technologies to aid in their disaster preparedness and management.

a. Uttarakhand, India: Big Data and disaster risk management

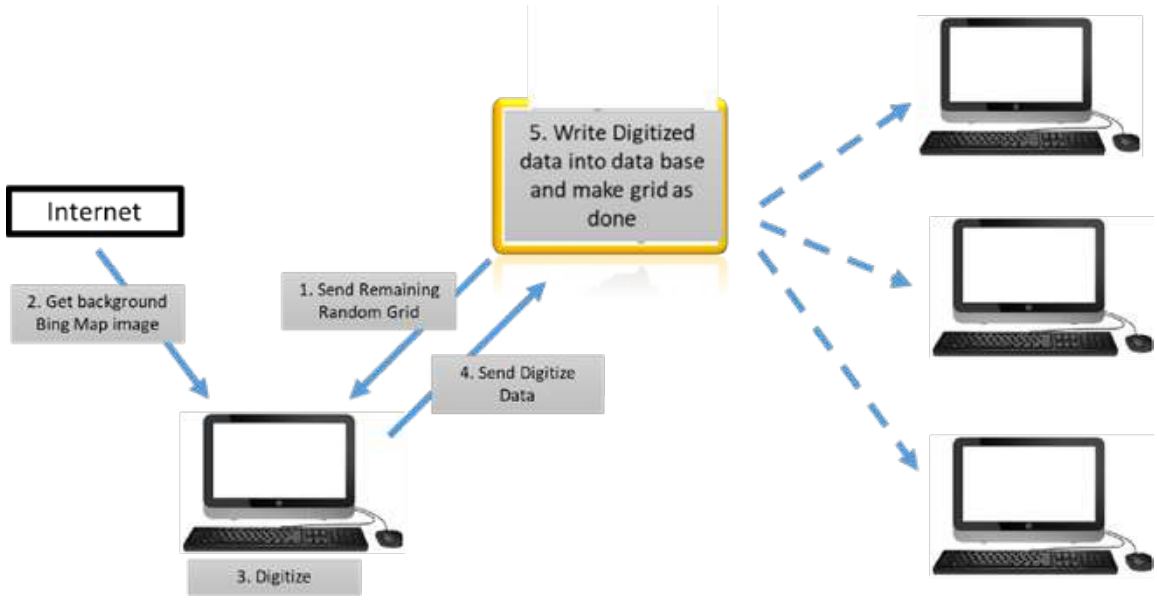
Effective and innovative Big Data processing and analysis is becoming increasingly important for risk assessment in data-scarce locations, particularly when defining and scaling up the present human and economic value of assets and when characterizing the natural hazards to which they may be exposed. This is driven primarily by dramatic increases in the volume and spatial/temporal resolution of remotely-sensed datasets and by social media sourced derivatives. Here, we present a few examples from Uttarakhand.

In January 2019, with financial support from the World Bank, the Uttarakhand State Government engaged a team of experts from DHI Water & Environment (S) Pte. Ltd, the Asian Institute of Technology (AIT) and the Evaluación de Riesgos Naturales (ERN), to complete a disaster risk assessment of the entire state and quantify, for the first time, the threat from natural hazards and the exposure of communities and critical infrastructure.

It was found that buildings are one of the major elements-at-risk. To overcome a gap of accurate information on the location of buildings, all building clusters and individual (distinctly standalone) buildings, in Uttarakhand, were digitized from high-resolution satellite images covering the whole state (an area of 53,483 km^2). Considering the large number of buildings in Uttarakhand, the whole state was divided into 60,000 grids that were each randomly assigned to a data entry operator for digitizing using an application. Figure 3.1 depicts the workflow of the tool, developed for rapid and collaborative efforts, that captures the building clusters for the entire state.

To be able to model the potential building losses, the team defined a set of typical building types (with consideration to varying vulnerability to hazards), and

Figure 3.1 Workflow of the innovative tool used to capture building clusters for Uttarakhand State



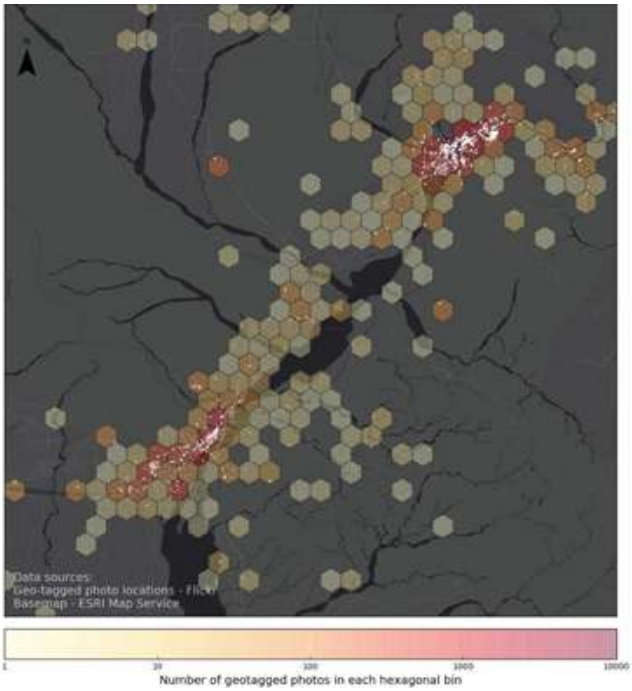
Source: Geoinformatic Center, AIT

then estimated the proportion of each type in every settlement across the state. This was achieved by using a variety of Big Datasets and remotely-sensed data, such as topography and night-time light. These datasets were fed into a machine learning algorithm and then trained and validated using the results of detailed field surveys in representative villages and towns.

Big Data also proved useful in modelling the spatial distribution of tourists and tourism activity around the state, which is significant, both in terms of its economic value but also because tourists are often a highly exposed sub-set of the human population with limited risk knowledge of the place they are visiting. Zones of high tourism activity were defined based on hundreds of thousands of anonymized spatial points, drawn from tourism booking and the review of websites listing hotels, restaurants and attractions, as well as photos posted on social media. Geolocating and characterizing these photos revealed popular hotspots, including informal infrastructures, such as tea-houses at highway viewpoints (Figure 3.2).

Another example shows how space data helps improve hazard forecasting and modelling. To be reliable, flood hazard models require high resolution and consistent weather datasets. Despite considerable efforts in modernizing its weather station networks, some parts of India do not currently possess adequate information from ground monitoring alone. In Uttarakhand, the team applied local weather data enhancement using alternative data sources, including satellite-based rainfall products (specifically, GPM and CHIRPS), together with other weather variables from the European Centre for Medium-Range Weather Forecasts (ECMWF) ERA-Interim climate models to produce final flood hazard and risk maps. In Uttarakhand, the team of experts statistically downscaled an ensemble of 14 climate projections to evaluate the impacts of climate change on local floods.

Figure 3.2 Example of geotagged photos indicating hotspots and density of tourism activity during the tourist season around Rishikesh and Haridwar, Uttarakhand



Source: Geoinformatics Center, AIT.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

The multi-hazard risk maps developed for Uttarakhand are now being fed into a decision support system (DSS) for better disaster management in the state. The DSS integrates both baseline and real-time data to support the emergency operation centre at the state-level. For example, during the rainy season, the DSS will select the closest hazard and risk map in the at-risk areas and enable the authorities to plan the response activities for an effective management of the disaster.

b. Philippines: A multi-agency initiative for disaster risk information: GeoRiskPH

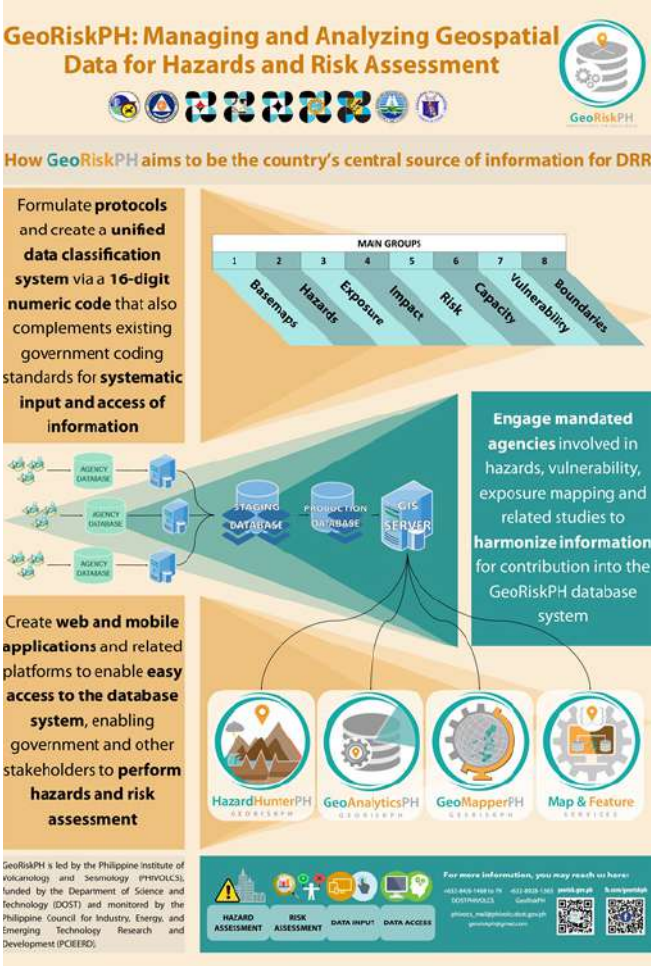
GeoRiskPH is a multi-agency initiative led by the Philippine Institute of Volcanology and Seismology that aims to be the central source of accurate and efficient information on hazards and disaster risks (Figure 3.3).[6] It is an innovative webGIS platform that uses crowdsourced data for geohazard mapping of disaster-prone areas in the Philippines. Conceptualized in 2017, the GeoRiskPH was approved to be the national platform for hazards and risk assessment in 2019, by the Cabinet of Philippines. Since the launch of GeoRiskPH, the Philippine Cabinet Cluster on Climate Change Adaptation, Mitigation and Disaster Risk Reduction (CCAM-DRR) has been using this platform to inform preparation and mitigation against natural hazards. Additionally, the Philippine National Land Use Committee has been using the platform to develop the National Exposure Database, which ensures the availability of nationally consistent data for disaster and climate risk reduction plans. In early

[6] GeoRisk Philippines, "Geospatial Information Management and Analysis Project for Hazards and Risk Assessment in the Philippines". Available at https://www.georisk.gov.ph/home

2020, the GeoRiskPH actively informed the responses during the eruption of Mt. Taal in Southern Luzon.

Currently, the GeoRiskPH platform offers three analytical tools: the HazardHunterPH, the GeoAnalyticsPH, and the GeoMapperPH launched in July 2020. The HazardHunterPH can detect and simultaneously assess natural hazards at any location. The GeoAnalyticsPH can generate maps, charts, and other analytics products based on the hazards, exposure, and location data from the entire GeoRiskPH database. The newest member, the GeoMapperPH collects hazard and exposure information from both official channels and fields to ensure accurate and timely updates in the GeoRiskPH databses.

Figure 3.3 The Operational Structure of GeoRiskPH



Source: GeoMapperPH, "Exposure Data Mapper (EDM) and Situation Data Mapper (SDM)". Available at https://geomapper.georisk.gov.ph/

c. Australia: Bushfire safety applications

Similarly, during the Australian bushfire crisis that lasted from September 2019 until February 2020, many Australian states launched and created bushfire safety applications to disseminate fire warnings and information to the public.

One of the widely used applications was the 'Fires Near Me' application developed by the New South Wales (NSW) State Government and the NSW Rural Fire Service,[7] due to the prevalence of bushfires near the population in New South Wales (Figure 3.4). This application was frequently updated and showed the different severity levels of fire. It also tracked the user's location and sent out alerts to smartphones if a fire was approaching. Many other states within Australia also developed and created similar mobile applications using geospatial data to disseminate information.

GeoScience Australia has also developed the Digital Earth Australia Hotspots portal which provides access to current information on nationwide fire hotspots registered by satellites (Figure 3.5).[8] Digital Earth Australia Hotspots is a national bushfire monitoring system that provides timely information about hotspots to emergency service managers across Australia. The mapping system uses satellite sensors to detect areas producing high levels of infrared radiation (called Hotspots) accurately, in order to allow users to identify potential fire locations with a possible risk to communities and property.

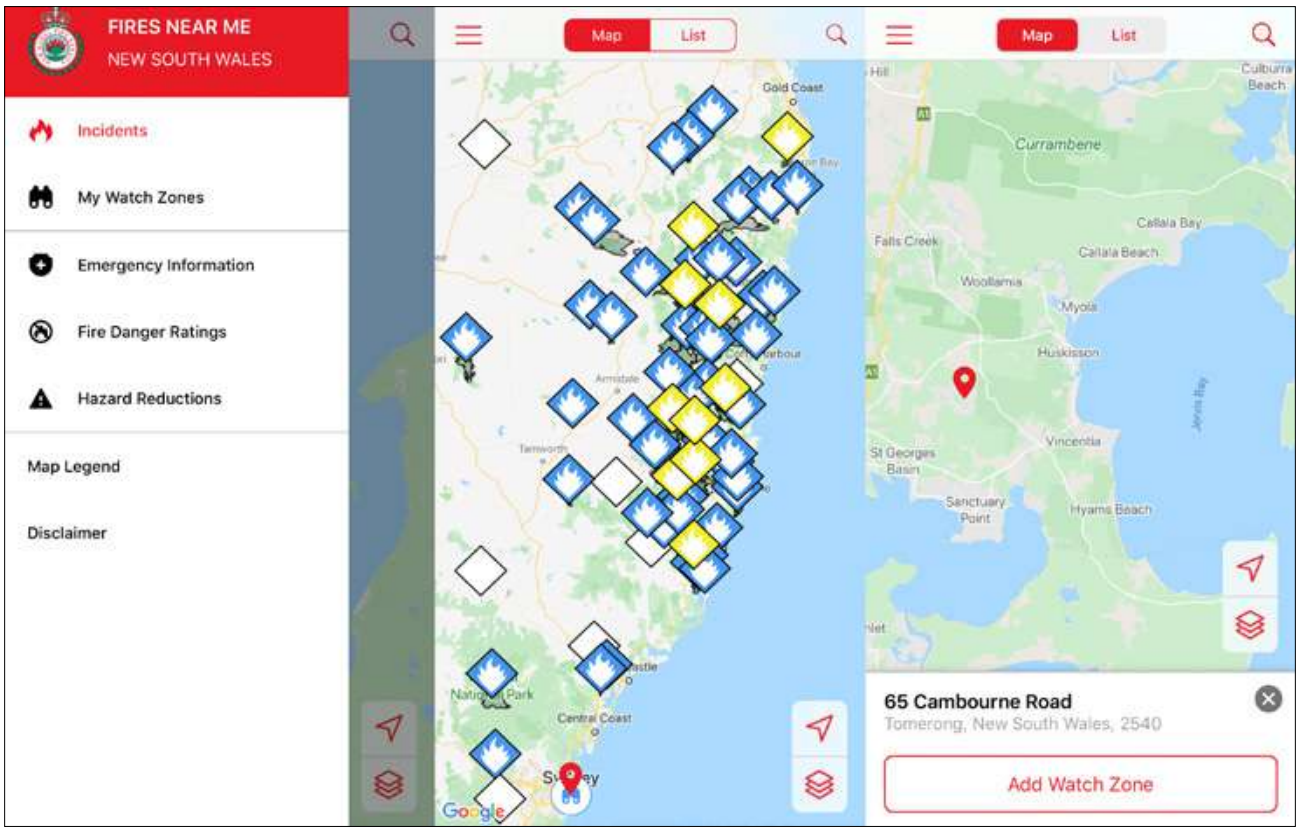
4. Disaster assessment and emergency response

In the Asia-Pacific region, many countries already utilize space applications and geospatial information for disaster risk reduction, specifically in the area of disaster monitoring and assessment, emergency response, hazard identification, communication and information. Furthermore, capacity-building activities are being conducted in order to share knowledge in the region and help countries build capacity and resilience to natural hazards.

[7] NSW Government, New Rural Fire Service. Available at https://www.rfs.nsw.gov.au/fire-information/fires-near-me

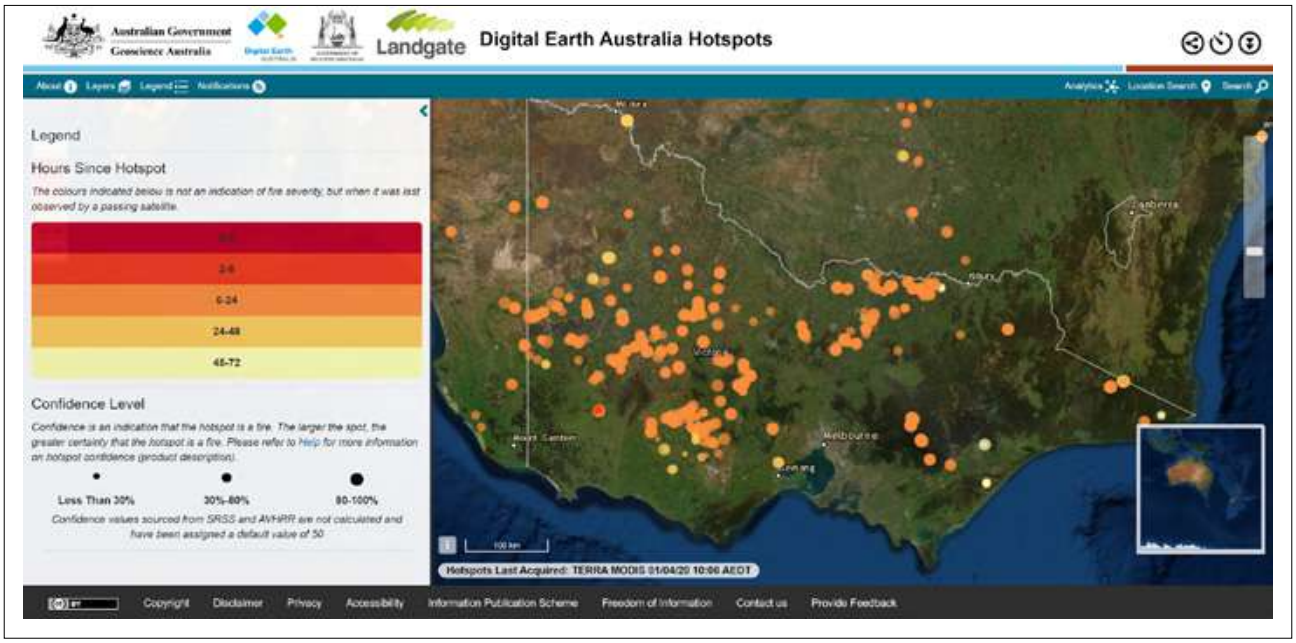
[8] Australian Government, Geoscience Australia, "DEA Hotspots". Available at https://hotspots.dea.ga.gov.au/

Figure 3.4 Screenshots of the mobile application "Fires Near Me" used to identify fire areas in New South Wales, Australia



Source: New South Wales Rural Fire Service
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Figure 3.5 A Screenshot of the Digital Earth Australia Hotspots portal



Source: Created by GeoScience Australia.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

A few examples of geospatial information for disaster monitoring and response within the region include:

- The Islamic Republic of Iran is using Earth Observation data for flood monitoring, warning, delineation and damage estimation and generated rapid-post-disaster damage estimations and displacement maps using satellite optical data after the Sarpol-e Zahab earthquake, in November 2018, and the Turkmenchay earthquake in November 2019.
- India, Mongolia, Pakistan, Sri Lanka and Thailand, amongst others, are utilizing space applications for drought monitoring and water management.
- Armenia and the Islamic Republic of Iran are using forest management and planning to help monitor forest fires.
- In Armenia, authorities calculated and mapped over 2,000 hectares of forest land which were impacted by a fire that began in the Khosrov Forest State Reserve.[9]
- Additionally, geospatial information is used for marine disaster mitigation as well as predicting fault lines and positions for earthquakes in Pakistan, Thailand, and other countries in the region.
- In the Philippines, hazard maps are being translated to the local level for integrated scenario-based, municipal-level risk assessments, combining geospatial data and citizen-contributed, ground-level risk information.

a. Satellite data and information for disaster risk

Satellite data is an important tool that plays a large part in understanding many environmental applications, such as disaster risk reduction, meteorological changes, and climate and water patterns. National space agencies, such as the Indian Space Research Organisation (ISRO), the National Institute of Aeronautics and Space (LAPAN) from Indonesia, and the Korean Aerospace Research Institute (KARI) from the Republic of Korea are providing satellite images to support disaster response. Countries and international organizations work together through mechanisms like the International Charter on "Space and Major Disasters", and complementary mechanisms like *Sentinel Asia* or ChinaGEOSS Disaster Data Response Mechanisms,[10] as part of the Asia-Oceania Group on Earth Observations (AOGEO).

The WMO Space Programme Regional Activities II and V Survey on the Use of Satellite Data, 2020, found that the top weather-related hazards identified for satellite detections and monitoring, within the region, were those related to lightning, flash flooding and tropical cyclones.[11] The available new-generation satellite data can now provide improved forecasting ability for countries and help them to prepare and respond to disasters and other environmental hazards. For instance, the Asian and Pacific Centre for the Development of Disaster Information Management (ESCAP-APDIM) has been using satellite data for sand and dust storms risk assessments, trends and impact-based forecasts.

b. India: Early detection of the severe cyclonic storm Fani, 2019

The 2019 cyclonic storm Fani was one of the severest cyclones, in the past two decades, to hit the Bay of Bengal, affecting around 100 million people in South Asia. The cyclone travelled from India's Andaman Islands to Mount Everest in Nepal. Among the countries impacted along its way, India and Bangladesh faced the most extreme damages. A similar cyclone, the Odisha cyclone that occurred in 1999, caused more than 10,000 deaths in these two countries. However, in 2019, the death toll was contained to 81 people due to early warning systems, detection, robust disaster preparedness and response systems, and accurate forecasts.[12, 13]

On April 26th, the India Meteorological Department (IMD) was able to pick up signals of Fani as a tropical depression, seven days before its landfall

[9] This information was shared by Armenia in their survey response.

[10] See ChinaGEOSS Data Sharing Network. Available at http://www.chinageoss.cn/en/index.html and Group on Earth Observations, "China GEO supports Brazil dam collapse disaster response", 12 March 2019. Available at https://www.earthobservations.org/article.php?id=339

[11] World Meteorological Organization (WMO), "Space Programme: RA II and RA V Survey on the use of Satellite Data", 2020. Available at https://public.wmo.int/en/resources/library/space-programme-ra-ii-and-ra-v-survey-use-of-satellite-data

[12] AON, "Global Catastrophe Recap: First half of 2019", July 2019. Available at http://thoughtleadership.aonbenfield.com//Documents/20190723-analytics-if-1h-global-report.pdf

[13] A. R. Subbiah and Kareff Rafisura, "Beyond just weathering the next storm: Odisha's experience and lessons for Mozambique and elsewhere", RIMES, 15 May 2019. Available at http://www.rimes.int/sites/default/files/odisha_weather.pdf

in Odisha.[14] Throughout the lifecycle of the cyclone, meteorologists used imagery from ISRO's SCATSAT-1 satellite to track the location, direction, and intensity of winds close to the ocean surface. To predict the path of cyclone Fani, two ocean-atmospheric coupled simulation models were used with the data from Doppler radars distributed across India (Kolkata, Chennai, Gopalpur, Paradip, and Machilipatnam).[15] Informed by accurate predictions, IMD was able to alert state authorities and district administrations of the cyclone, and provide ground authorities with hourly updates through bulletins, WhatsApp groups, and emails.[16] As a result, India successfully evacuated and sheltered 1,470,197 people. Together with the 1 million population evacuated in Bangladesh, these two South Asian countries accomplished one of the biggest human evacuations in history.[17]

[14] International Federation of Red Cross and Red Crescent Societies, "Asia Pacific: Cyclone Fani Information bulletin", Situation report, 30 April 2019. Available at https://reliefweb.int/report/india/asia-pacific-cyclone-fani-information-bulletin

[15] Giulia Roder, "Cyclone Fani: A success in weather forecast and disaster preparedness", European Geosciences Union (EGU) Blogs, 20 August 2019. Available at https://blogs.egu.eu/divisions/nh/2019/08/20/cyclone-fani-a-success-in-weather-forecast-and-disaster-preparedness/

[16] Ibid.

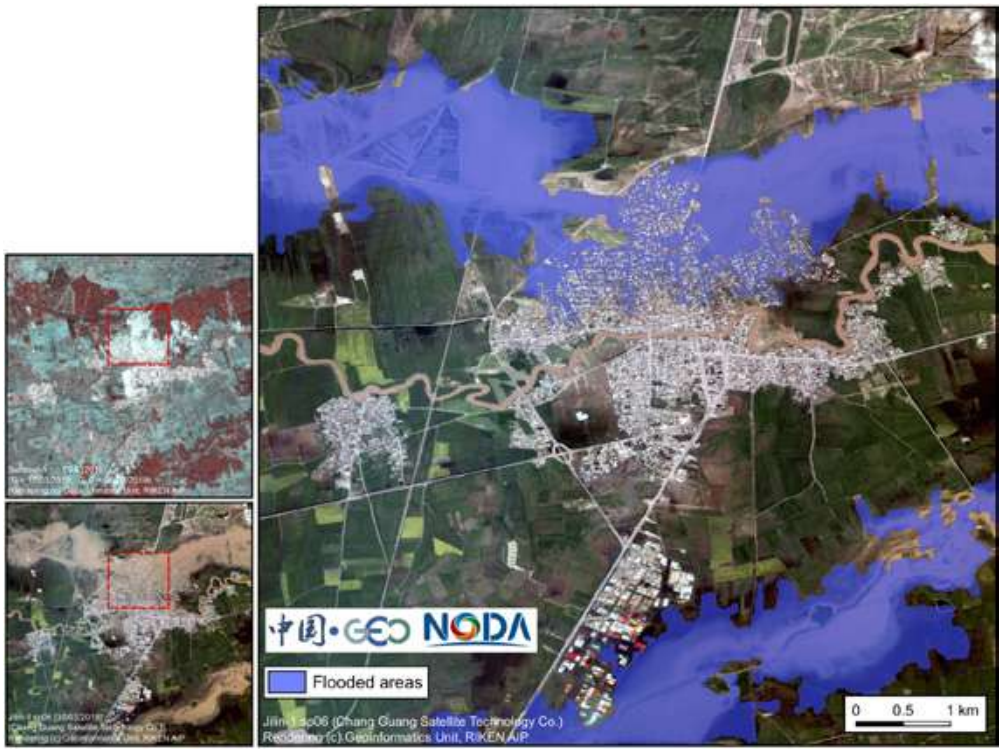
[17] Indian Red Cross Society, "Odisha FANI cyclone assessment report". Available at https://www.indianredcross.org/notices/OdishaFaniAsessmentReport.pdf

c. The Islamic Republic of Iran: High resolution satellite images for flood responses

Record rainfall and flooding in the Islamic Republic of Iran led to substantial loss of life and forced evacuations of thousands of people since mid-March 2019, causing hundreds of millions of dollars of damage. Responding to requests from ESCAP and the Iranian Earthquake Engineering Association, China GEO activated its Disaster Data Response Mechanism (CDDR) to provide high-resolution satellite imagery in support of disaster response planning (Figure 3.6).

The Islamic Republic of Iran's Mehr News Agency reported that 1,900 cities and villages were flooded, while other news outlets reported that more than 140 rivers had burst their banks; 409 landslides had occurred; 78 roads had been blocked; and 84 bridges had been affected. Rapid access to high resolution satellite images is important for government agencies and first responders to assess damage, and prioritise and plan their response operations. Following the activation of the CDDR for the Islamic Republic of

Figure 3.6 High-resolution satellite images provided to the Islamic Republic of Iran by the ChinaGEOSS Disaster Data Response Mechanism in support of disaster response in flooded regions



Source: China NODA
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Iran's flooded areas in Aq Qala, Darvazeh Quran and Pol Dokhtar, it was able to provide high-resolution satellite images (0.92 meters) to support disaster response.

Such timely data and analysis helped the Iranian Space Agency, the Ministry of Communications and Information Technology National Disaster Management Organization of Iran and the Iranian Red Crescent Society with their flood-related activities. By setting up a specialized Technical Team within these agencies, more than ten flood events were effectively monitored in the past two years and many useful maps related to floods were released.

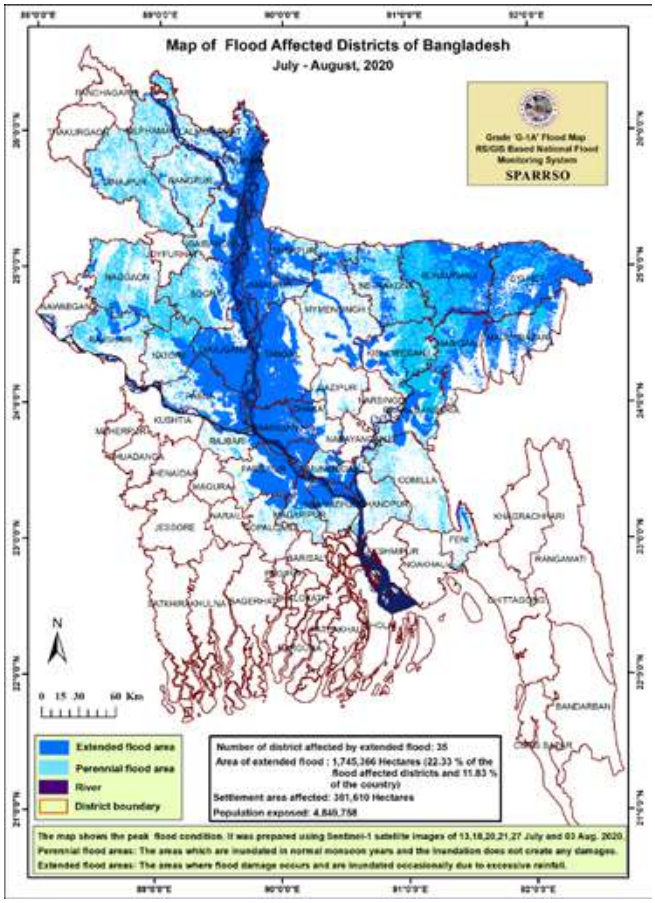
d. Bangladesh: Extended flood area mapping system

Bangladesh faces potential flooding every monsoon season. To address this problem, the Bangladesh Space Research and Remote Sensing Organization (SPARRSO) has established an extended flood area mapping system, by incorporating a perennial flood data layer with layers extracted from remotely sensed imagery, in order to improve flood information for post-flood relief and rehabilitation activities.

During a normal monsoon in Bangladesh, the flooding remains at a perennial level and does not cause any damage. However, when the water extends beyond the normal levels, a perennial flood turns into an extended flood. Satellite remote sensing is a reliable source of data for flood mapping, however, if used individually, remote sensing can only estimate the gross flood area (perennial + extended). Mapping the gross flood area is not sufficient for flood managers because, for effective relief and rehabilitation activities, information on the area where the actual flood damage occurs is needed.

Therefore, SPARRSO has developed a complex multi-layer flood area model to estimate extended flood areas based on satellite images. Multi-temporal, remotely sensed images of normal monsoon years were synthesized in order to generate the critical perennial flood area data layer beyond which damages occur if the flooding extends. Having the extended flood mapping system in place was key to quickly share and incorporate the helpful information it generated to inform disaster response efforts during the July 2020 flooding in Bangladesh.

Figure 3.7 Flood affected districts of Bangladesh, July – August 2020



Source: Provided to ESCAP as part of survey response by SPARRSO, 2020. Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

e. Kingdom of Tonga: Initial damage disaster report for tropical cyclone Harold

In early April 2020, tropical cyclone Harold, a severe category 5 cyclone, hit countries within the Pacific region, causing major damage and widespread destruction (Figure 3.8). Following the cyclone, the National Emergency Management Office (NEMO) in the Kingdom of Tonga, under the Ministry of Meteorology, Energy, Information, Disaster Management, Environment, Climate Change and Communications (MEIDECC), and together with supporting ministries and humanitarian agencies, acted quickly to lead and coordinate the Initial Damage Assessment (IDA) at the household level across Tongatapu and 'Eua and other affected areas (Figure 3.9). The IDA was undertaken by conducting household interviews, damage verification and observation and remote

sensing surveying using unmanned aerial vehicles (UAVs.) Figure 3.9 demonstrates the areas where the IDA survey was carried out using KoboTool where overall maps were generated, reaching a total of 3,950 households (23 per cent of total households) across Tongatapu and 'Eua. It was estimated that approximately 10 per cent of households in Tongatapu and 'Eua were significantly impacted and needed urgent relief, with over 1,400 people being displaced. Patangata (Kolofo'ou District) experienced severe flooding during tropical cyclone Harold, as can be seen in Figure 3.8. The area of dryland that was used for living is now thinner and more exposed to flooding.

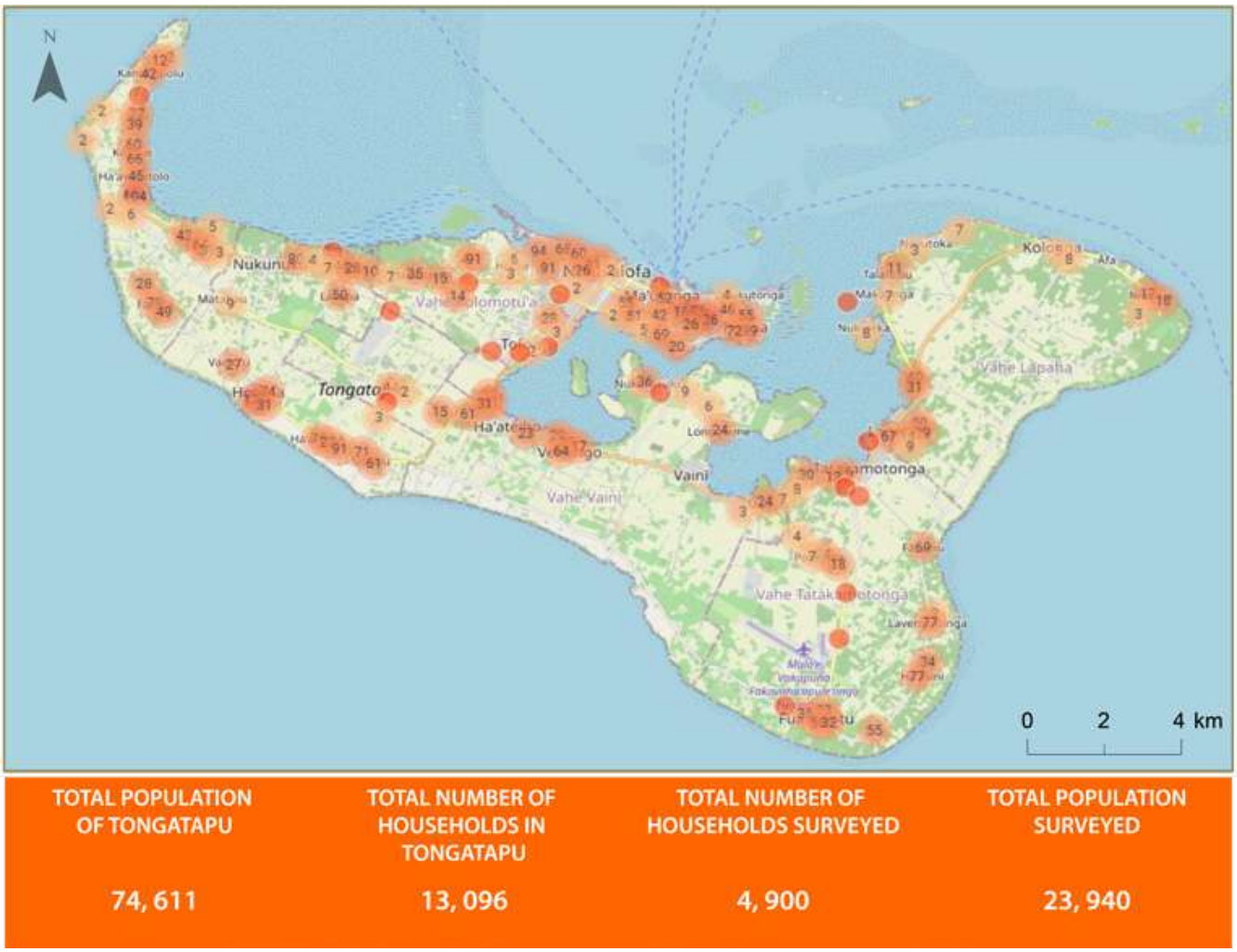
With assistance from the MORDI Tonga Trust, an International Fund for Agricultural Development, a UAV damage assessment survey was undertaken using small scale UAVs. These surveys, undertaken in high damage areas, showed major differences between the pre- and post-disaster scenarios in terms of severe land and building damage. Using space and geospatial applications, such as UAVs, post disaster assessments provide accurate, high resolution and quick imagery of the damage which would be difficult or expensive to gain elsewhere. Through the use of UAV surveying, areas of high concern can be quickly identified in order to alert authorities of where aid and support needs to be directed.

The cyclone caused widespread damage to not only people and property, but also to local infrastructure and agricultural areas, such as crops and trees. This impacted and strained the local communities who rely on these services for their livelihoods. Many people living within these communities do not have other means of acquiring these services, such as food and water, and required urgent support. Upon completion of the surveys, it was found that many households had poor access to clean drinking water, electricity, reliable food sources and basic necessities, and 25 per cent of households had damaged kitchens or toilets. This information was then used for recovery efforts by providing recommendations to aid priority areas where immediate action was needed. This included priority to both communities and households, as well as mid- to long-term priorities in supporting and rebuilding households.

Figure 3.8 Drone images showing severe flooding during Tropical Cyclone Harold in the Patangata Village, Kolofo'ou District, Kingdom of Tonga

Source: Mainstreaming of Rural Development Innovation (MORDI) Tonga Trust. See, https://www.gov.to/press-release/initial-damage-assessment-ida-for-tropical-cyclone-harold/
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Figure 3.9 Areas where the IDA survey was carried out in Tongatapu



Source: National Emergency Management Office (NEMO) Tonga Trust. See, https://www.gov.to/press-release/initial-damage-assessment-ida-for-tropical-cyclone-harold/
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

f. Pakistan: Specialized Space Application Centre for Response in Emergency and Disasters

Pakistan has been affected by devastating hydro-metrological disasters for the last several years. The Space and Upper Atmosphere Research Commission (SUPARCO) of Pakistan established a specialized Space Application Centre for Response in Emergency and Disasters (SACRED) and is also host to the UN-SPIDER Regional Support Office. Moreover, SACRED-SUPARCO is a member of Sentinel Asia's Data Analysis Node (DAN). SACRED-SUPARCO provides near real time space-based support to the National Disaster Management Agency (NDMA)/Provincial Disaster Management Agencies (PDMAs) in the event of natural disasters, such as floods, drought, landslides, glacial lake outburst flooding (GLOF), glacier surging and earthquakes.

SUPARCO developed the DisasterWatch Web Portal for near real time dissemination of space-based information to NDMA/PDMAs in the event of natural disasters.[18] DisasterWatch is being actively used for disaster monitoring, response and relief activities since 2015.

[18] Pakistan Space and Upper Atmosphere Research Commission (SUPARCO). "Disaster Watch". Available at disasterwatch.sgs-suparco.gov.pk

Figure 3.10 **DisasterWatch web portal for near real time dissemination of space-based information**

Source: DisasterWatch web portal, SUPARCO.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Additionally, SUPARCO is currently undertaking the National Catastrophe Modelling Project for the National Disaster Risk Management Fund (NDRMF) for earthquakes, floods, droughts, and tropical cyclones. The model will eventually help decision makers in Pakistan to be able to quantify the Total Value at Risk (TVAR). It will include the development of a national, spatial geo-referenced GIS dynamic database for public and private assets and infrastructure (agriculture, livestock, infrastructure, buildings) the associated physical vulnerability to different types of natural hazards of varying intensity and their reconstruction costs.

g. The Russian Federation: Co-deployment for risk monitoring - Cospas-Sarsat

The Russian Federation is the latest contributor to the space segment of the International Cospas-Sarsat programme. Cospas-Sarsat is a global search-and-rescue system established in 1988, and currently involves 45 participant states and agencies, including four founding satellite providers (Canada, France, Russia and USA). More than 30,000 lives were saved since its inception thanks to the SOS-beacon activations, which allow emergency services to locate a person in distress in less than five minutes anywhere on the Earth's surface. The mechanism's space segment currently contains 25 satellites in low, medium and geostationary orbits. The most recent contribution was the launch of a Russian meteorological Low Earth Orbit (LEO) Meteor M №2-2 satellite, where the Cospas-14 payload was installed in addition to the multispectral imagers as part of a co-deployment scheme. Usually co-deployment allows to lower capital infrastructure costs and generate useful data, which is the main reason for its increasing popularity in the transport and energy sectors.[19] In the case of Cospas-Sarsat, however, co-deployment allows the project to exist and assist in saving lives since its services are complimentary for users and there are no satellites specifically dedicated to search-and-rescue purposes.

[19] United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), "Subregional workshop on ICT co-deployment along passive infrastructure in South Asia", New Delhi, 27 June 2019. Available at https://www.unescap.org/events/subregional-workshop-ict-co-deployment-along-passive-infrastructure-south-asia

5. An international call for support when disasters strike

When disaster strikes, countries have regional and international options to reach out for support in order to use space technology to assist emergency planning and emergency responders. For example, in times of disaster and emergency, to avoid the loss of life and minimize economic losses, ESCAP responds promptly, through the RESAP, to requests for support by disaster affected Member States, by facilitating the two-way sharing of geospatial information between the country focal points who know the exact location of where information is needed, and the countries who can provide the imagery quickly (see cyclone Fani example below).

The Rapid Mapping Service of the United Nations Institute for Training and Research Operational Satellite Application Programme (UNITAR-UNOSAT) is also on-call 24 hours a day to address disasters on behalf of Member States and other partners. These rapid mapping efforts are expected to enhance evidence-based decision-making amongst humanitarian actors during major disaster events.

From 2017 to 2020 UNITAR-UNOSAT produced 269376 maps and 111147 reports, (examples of these maps can be seen in Figure 3.11). Most of the major disaster events came in the form of floods, tropical cyclones, and earthquakes. Since 2019, UNOSAT has extended humanitarian rapid mapping support to ESCAP Member States for 2231 disaster events. The services included 7179 satellite images that allowed for timely decision-making covering different natural hazards. Since 2016, UNOSAT has collocated its regional team in ESCAP with the Information and Communication Technology and Disaster Risk Reduction Division to work together with the space applications team to support ESCAP Member States in disaster response and damage assessment.

Countries in the Asia-Pacific region are also providing free maps for the public, as in the Philippines, where the University of the Philippines Training Center for Applied Geodesy and Photogrammetry generated high-resolution maps using the Light Detection and Ranging (LiDAR) technology, with the resolution of up to 1x1 meters. These open access maps can now be used for the planning and reconstruction of areas damaged by the Taal volcano which erupted in January 2020.[20]

[20] Teresa Umali, "University of the Philippines to open map data for Taal volcano rehabilitation", OpenGov Asia, 29 January 2020. Available at https://www.opengovasia.com/university-of-the-philippines-to-open-map-data-for-taal-volcano-rehabilitation/

Figure 3.11 Buildings damage assessment and related density using very high-resolution satellite imagery for Tropical Cyclone Harold-20, Vanuatu

Source: United Nations Institute for Training and Research (UNITAR), "Vanuatu Maps". Available at https://unitar.org/maps/countries/109
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Furthermore, the International Charter on 'Space and Major Disasters',[21] and Sentinel Asia,[22] are global and regional initiatives that aim to provide satellite data for disaster management. Countries in the Asia-Pacific region play an important role in supporting these initiatives and providing invaluable geospatial information in times of need. The following examples illustrate a few of these recent instances.

a. International Charter to assist in cyclone 'Fani'

On average, the International Space Charter provides support to approximately 40 major disasters annually and across the world. In May 2019, a severe cyclonic storm, 'Fani', made landfall in the East coast of Odisha, India, and the International Charter was activated by the ISRO. During '*Fani*', 162 satellite images from 18 satellites were provided to rescue teams in Odisha. These datasets were used for sharing near real-time information on the cyclone's impact in the affected areas. Maps showing inundated areas were prepared almost on a daily basis during 3 to 10 May 2019, and were widely used by the state and central authorities. Furthermore, very high-resolution satellite data was used to assess the damage to infrastructure, which formed part of post-disaster recovery and construction. India does not only receive remote sensing data from various International Space Agencies during emergencies, but shares its own data as well to support various disaster events across the globe.

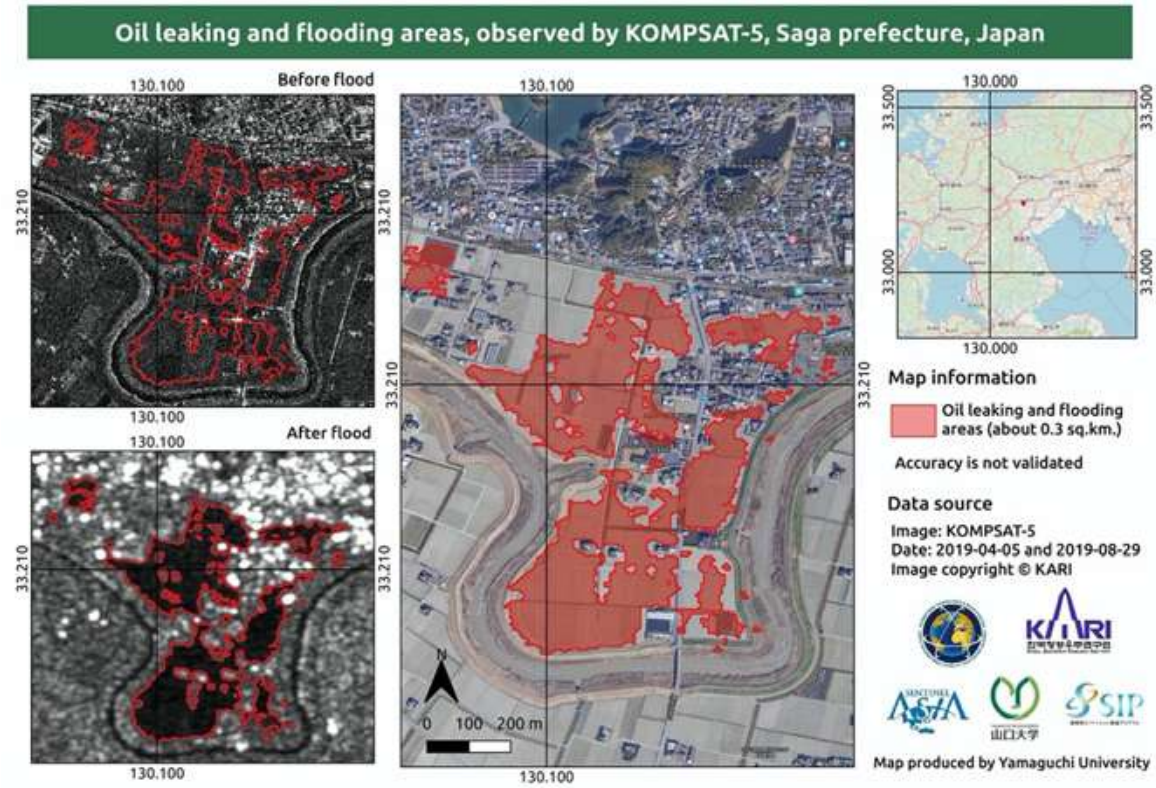
During cyclone 'Fani', Bangladesh used the international mechanisms available for support as well. ESCAP activated, on request of SPARRSO, the RESAP that worked with spacefaring member countries to provide real time access to satellite images to support post-cyclone response and early recovery operations. Further, ESCAP, through the collocated UNITAR/UNOSAT office, facilitated the activation of the International Charter for Bangladesh as well.

Many space agencies, from countries within Asia and the Pacific that are members of the International

[21] The International Charter Space and Major Disasters. Available at https://disasterscharter.org/web/guest/home

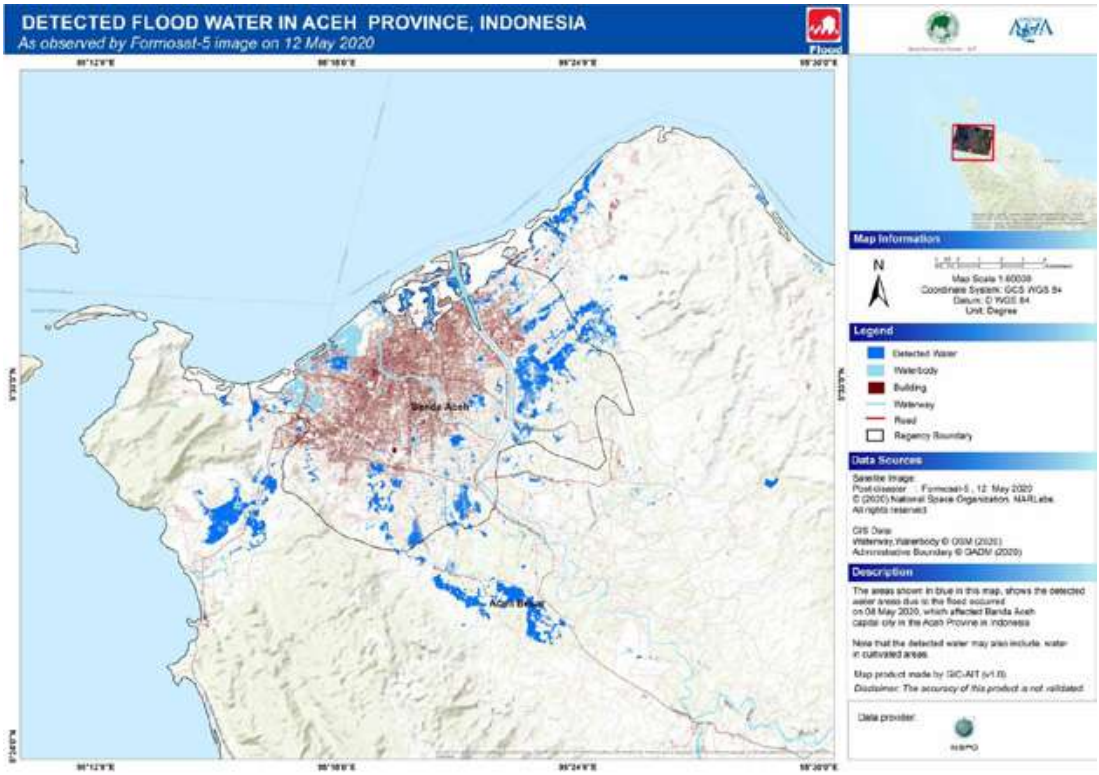
[22] Sentinel Asia. Available at https://sentinel-asia.org/index.html

Figure 3.12 Sample imagery from KOPMSAT-5 by KARI for oil leaking and flooding areas



Source: KARI, Map by Yamaguchi University.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Figure 3.13 Sample imagery of detected flood water in Indonesia



Source: Supplied by LAPAN.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Charter and Sentinel Asia, provide high-resolution satellite images in cases of disasters. The Korea Aerospace Research Institute (KARI) from the Republic of Korea provides over 500 satellite images, annually. In the case of a disaster, the sub-meter resolution of the KOPMSAT satellite imagery provides a detailed detection of damages incurred to small-scaled houses, roads and their surroundings (Figure 3.12).

b. Indonesia and Japan: Flood and landslides with imagery assistance

The National Institute of Aeronauts and Space (LAPAN), in Indonesia, also provides space-based information, especially in the context of preparedness and emergency response. As a disaster-prone country itself, LAPAN as an important partner for the Indonesian National Board for Disaster Management (BNPB), that provides images for disasters like floods, drought, fire hotspots, landslides, tsunamis, earthquakes and volcanic eruptions. The BNPB also uses Sentinel Asia to receive more data. Furthermore, during a severe flood in Banda Aceh, the Japan Aerospace Exploration Agency (JAXA), the ISRO and the National Atmospheric Research Laboratory (NARL) provided their satellite imagery. The images were then analysed by the Asian Institute of Technology (AIT), the Earth Observatory of Singapore, JAXA and LAPAN itself.

These maps and images acquired from the Space Charter and Sentinel Asia were used in conjunction with other data sources. The main benefit was the speed at which the damage estimation was produced. Within 10 to 14 days of the event, stakeholders were able to estimate losses and access the spatial distribution of damages. The assessment of damage was made using pre- and post-disaster scenarios that were captured by time series remote sensing data in conjunction with ground-based information, including drone and social media reports. The World Bank was able to make rapid estimates with total economic damages amounting to $US 500 million to programme its support of up to $1 billion for the Government of Indonesia to support recovery and reconstruction efforts.[23]

[23] World Bank, "World Bank announces $1bn assistance for Indonesia natural disaster recovery and preparedness", press release, 14 October 2018. Available at http://www.worldbank.org/en/news/press-release/2018/10/14/world-bank-announces-assistance-for-indonesia-natural-disaster-recovery-and-preparedness

6. Agroecosystem resilience: preparing for drought

Drought causes adverse impacts on ecosystems, agriculture, and socioeconomic conditions, threatening the achievement of the SDGs. Drought is a slow-onset disaster that usually starts unnoticed and develops cumulatively with impacts that vary from area to area. The Asia-Pacific region faces a new climate reality, where slow-onset disasters, such as drought, have been increasing and account for nearly two-thirds of disaster losses.[24] Furthermore, drought intensifies environmental degradation, undermines social development, and severely affects the livelihoods of vulnerable communities, particularly those dependent upon agriculture.

[24] The Disaster Riskscape Across Asia-Pacific: Pathways for Resilience, Inclusion and Empowerment- Asia-Pacific Disaster Report 2019 (United Nations publication, Sales No. E.19.II.F.12). Available at https://www.unescap.org/publications/asia-pacific-disaster-report-2019

Earth observation and fast emerging digital technologies offer great hope for progress and development and can be used in combination with surface-based observations to capture transboundary impacts and the origins of disasters, such as drought. To illustrate this, ESCAP's Regional Cooperative Mechanism for Drought Monitoring and Early Warning (Regional Drought Mechanism) provides a tailored and customized toolbox of data, products and services to support countries in building their capacity to apply Earth observation-based risk information for managing drought risk, and ultimately building resilience to drought.[25]

[25] For more details, see United Nations Economic and Social Commission of Asia and the Pacific, Information and Communications Technology and Disaster Risk Reduction Division, "Geospatial tools to support the implementation of the Sustainable Development Goals in Asia and the Pacific: the drought riskscape and the Regional Drought Mechanism", Staff technical paper series, December 2019. Available at https://www.unescap.org/resources/geospatial-tools-support-implementation-sustainable-development-goals-asia-and-pacific

Box 3 Earth observation data for drought resilience-building in South-East Asia

Different countries in South-East Asia are at varying stages of producing and utilizing space-based information for managing drought risk. A number of regional organizations and ongoing regional initiatives support South-East Asian countries in accessing and processing Earth observation data for drought monitoring. The Mekong River Commission provides drought updates and warning based on regionally-available products, such as those from SERVIR Mekong, as well as data for four indices: combined drought index, soil moisture deficit, standard precipitation, and standardized run-off.

There is a lot of scope to upscale the use of Earth observation data in operational drought monitoring and decision-making. It is important to continue building institutional capacities to set up digital systems for accessing, processing and integrating these Earth observation products and services into operational drought monitoring and early warning systems. Information alone is not enough to manage drought risk proactively. Thus, more critically, the next phase of capacity-building efforts should put a much stronger focus on bringing decision makers and other information users on board. The approach needs to transition from just promoting generic indicators and indices to tailoring them to the specific impacts that are relevant to the decision makers. Finally, building the capacity of institutions to use these indices to design and trigger early actions and adaptation measures is critical to building and improving societal resilience to drought.

In a region where ground-based information is generally scarce, remote sensing and Earth observation can reinforce the much-needed coverage for drought indicators. The gradual onset and decay of droughts, as well as their tendency to cover large swaths of land areas, lends drought to effective space-based monitoring. Many countries utilize varying levels of geospatial information for drought monitoring and resilience. This section will highlight examples from across Asia and the Pacific.

a. Regional Drought Mechanism

The Regional Drought Mechanism was initiated, in 2013, to address the scarcity of resources and capacity to analyse data in many drought-prone developing countries in Asia and the Pacific. It is a flagship programme of ESCAP, under RESAP, designed to enhance the capacity of Governments to use space-based data for effective drought monitoring and early warning. The mechanism applies science and technology to support countries in Asia and the Pacific to address the menace of drought through improved and effective decision-making. The mechanism has four components:

1. **Regional Service Nodes**, currently from China, India, and Thailand, that provide satellite imagery and services as well as capacity development to pilot countries in the region;

2. **Thematic and Scientific Communities** where diverse groups are networked together under specific thematic areas to advise on drought monitoring and early warning, preparedness and action;

3. **Pilot Countries** are selected upon the request to participate in the mechanism as beneficiaries of cutting-edge science and technology to better prepare for drought;

4. **The Agricultural Community** that directs the beneficiaries on the ground to proactively reduce the impacts from drought, based on sound knowledge and timely warning information from government institutions.

The Regional Drought Mechanism seeks to apply cutting-edge science and technology, bringing together public, private and scientific entities to enhance drought management and increase resilience. This is accomplished through a menu of tailored tools, products and services provided by Member States of ESCAP in the spirit of regional cooperation. This data and information driven regional cooperation can be replicated and adapted to different country contexts.

Table 3.2 Menu of tools, products and services by Regional Service Nodes for the Regional Drought Mechanism

Regional Service Node		Tool, product, service
Country	Institution	
India	Indian Space Research Organization (ISRO)	· Drought Monitoring System · Bhuvan Geo platform portal
China	Institute of Remote Sensing and Digital Earth (RADI), Chinese Academy of Sciences	· DroughtWatch · Field data collection app · Field campaign and validation methodology · Crop Bulletin methodology · CropWatch Cloud
Thailand	Geo-Informatics and Space Technology Development Agency (GISTDA)	· Thailand Drought Monitoring System · GISTDA Map Online Service

Note: These systems are tailored to country contexts and their data and provide detailed, localized forecasts that can be updated during the growing season to give more comprehensive real-time drought monitoring and early warning.

Table 3.3 Overview of the timeline for implementation of the Drought Mechanism in pilot countries 2013-2020

2013-2014	Cambodia, Kyrgyzstan, Mongolia, Myanmar and Sri Lanka committed to becoming pilot countries of the Regional Drought Mechanism. Consultation meeting in Mongolia.
2015	DroughtWatch system customized for and installed in Mongolia. Tailored capacity-building in pilot countries and development of drought monitoring system in Sri Lanka, and Cambodia with support of regional service nodes in China, India, Thailand begins.
2016	DroughtWatch calibrated and validated in Mongolia. Tailored capacity-building continues in pilot countries of Cambodia, Mongolia, and Sri Lanka, and begins in Myanmar with the support of regional service nodes in China, India, Thailand.
2017	DroughtWatch calibrated and validated in in Mongolia. Specific training and technical support provided to Cambodia, Mongolia, Myanmar, Sri Lanka.
2018	Training and technical support provided to Kyrgyzstan and Sri Lanka. Service for drought monitoring expanded to *dzud* monitoring in Mongolia and to crop monitoring in Cambodia, Myanmar and Viet Nam.
2019-2020	Training and technical support provided to Kyrgyzstan and Sri Lanka. Service for drought monitoring expanded to *dzud* monitoring in Mongolia and to crop monitoring in Cambodia, Myanmar and Viet Nam.

b. China's support to Mongolia under the Regional Drought Mechanism

The Institute of Remote Sensing and Digital Earth (RADI), recently renamed Aerospace Information Research Institute (AIR), under the Chinese Academy of Sciences, developed the DroughtWatch System. This is a multi-satellite, multi-scale drought monitoring system that includes an auto-processing chain from satellite data downloading, pre-processing, index calculation, drought monitoring, statistics and analysis, and data management. DroughtWatch has been deployed at the China Ministry of Water Resources and the China Ministry of Civil Affairs (now Ministry of Emergency Response), and is now being deployed at the State Meteorological Bureau.

To help address the challenges of drought monitoring, Mongolia became the first pilot country for ESCAP's Regional Drought Mechanism. The process began in 2013 following a request to ESCAP to pilot the Mechanism through the Mongolian National Remote Sensing Centre (NRSC) within the Information and Research Institute of Meteorology, Hydrology and Environment (IRIMHE).[26] Through the RESAP network, ESCAP facilitated matching Mongolia's needs with the ability, in particular from China, to provide customizable tools and expertise to enhance the capacity for drought monitoring and analysis for decision-making in the crop farming, forest, and pastoral animal husbandry sectors in Mongolia (Figure 3.15). Through a five-year developing and learning process, DroughtWatch-Mongolia was officially handed over to Mongolia, in September 2018, in full operation and having the ability to provide real-time drought monitoring for disaster prevention and mitigation. An exploration of this multi-year and multi-partner investment reveals how the Regional Drought Mechanism was tailored to local needs, with sustainability and future use in mind.

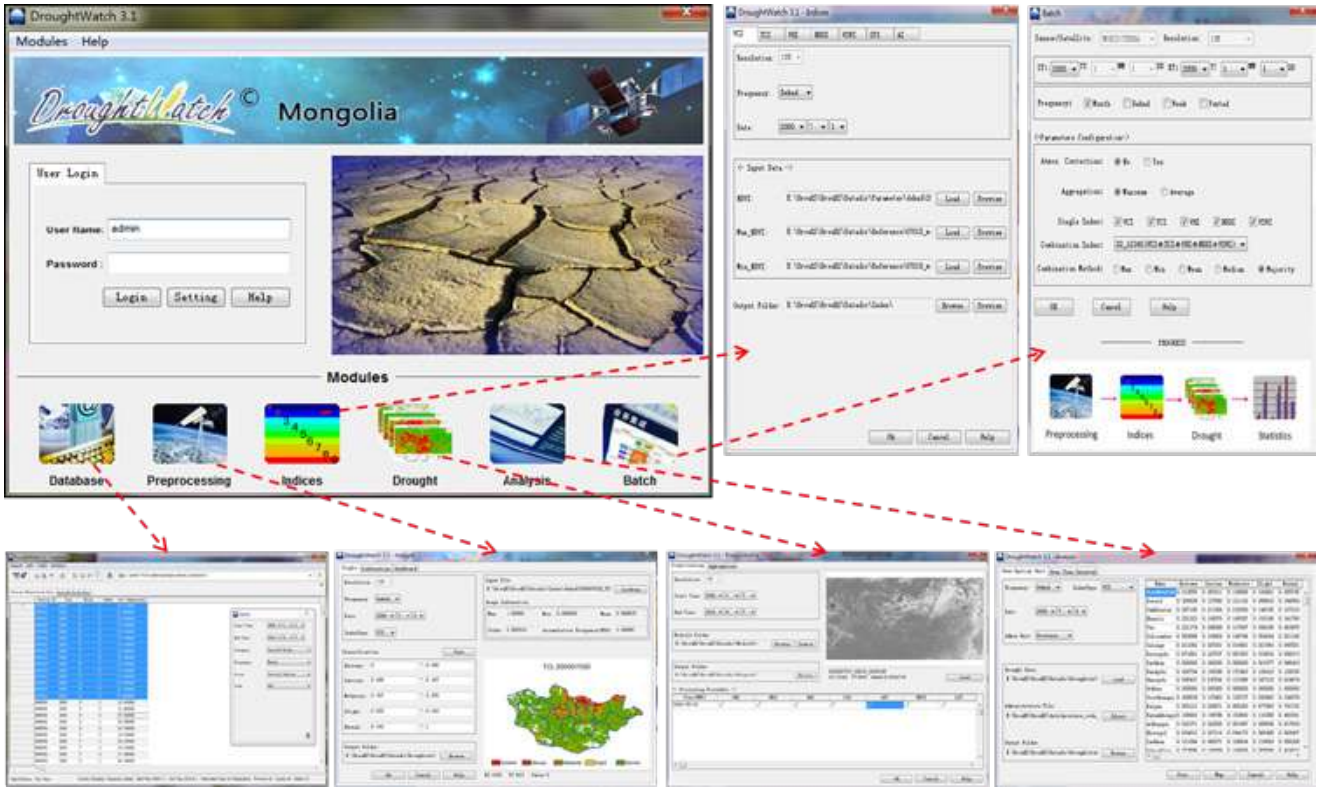
RADI provided training, DroughtWatch software after customization and calibration, relevant geospatial and climate data and expertise to tailor the drought monitoring tool to Mongolian conditions. This involved a series of capacity-building and technical training workshops for over 100 people by developing

[26] Ibid.

Figure 3.14 RADI experts during their field mission for validation of DroughtWatch in Mongolia, 2017

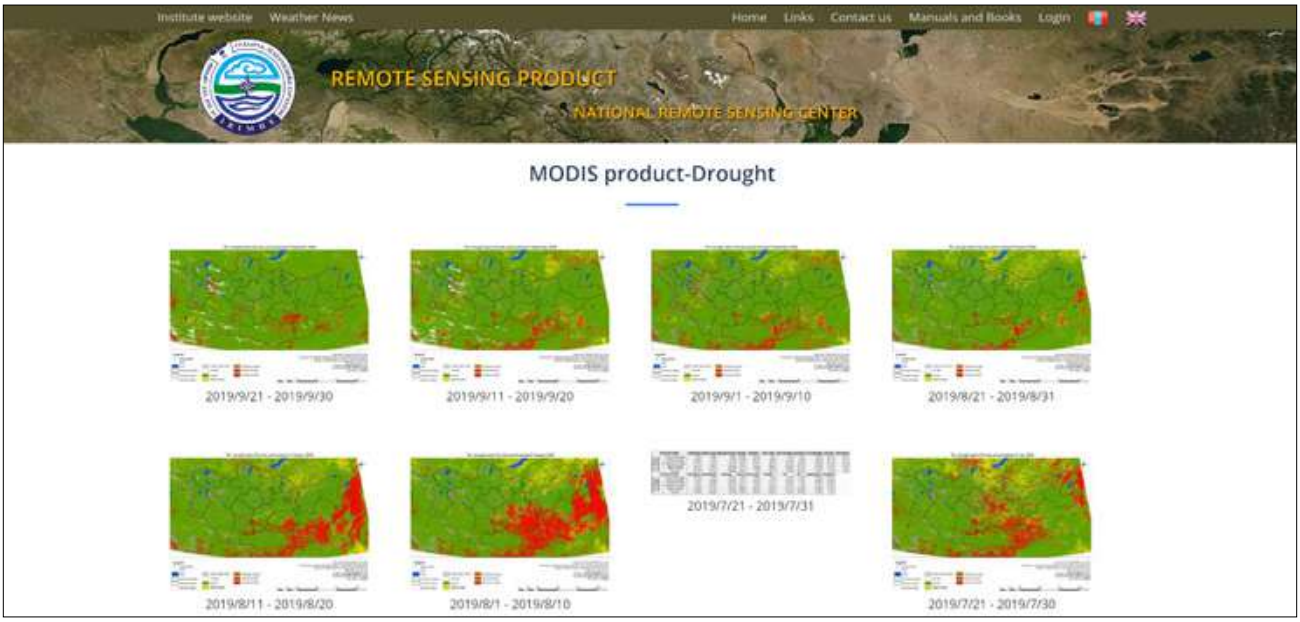
Source: The Institute of Remote Sensing and Digital Earth (RADI), 2017.

Figure 3.15 The DroughtWatch system customization for the Mongolian context and needs



Source: The Institute of Remote Sensing and Digital Earth (RADI).

Figure 3.16 **DroughtWatch-Mongolia products released on their National Remote Sensing Center website**



Source: Information and Research Institute of Meterology, Hydrology and Environment (IRIMHE), Remote Sensing Product, MODIS product-Drought. Available at http://www.icc.mn/index.php?menuitem=5&datatype=mdro
Note: The NRSC of Mongolia officially released the national drought monitoring report and information at Information and Research Institute of Meterology, Hydrology and Environment (IRIMHE). Available at http://irimhe.namem.gov.mn and at www.eic.mn
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

a manual, and a customized software dashboard. Drought products were distributed to all Mongolian provinces and AIR, along with local counterparts, conducted joint data processing. RADI provided on-the-job training for Mongolian counterparts (about 10 technical officials) during the customization, guidance for annual field surveys in selected drought-prone provinces, calibration of the model and results validation processes. Furthermore, it hosted three Mongolian students, who were sponsored by a fellowship of the Chinese Academy of Sciences, to further enhance technical capacity in Mongolia and sustainability of the system.

The DroughtWatch-Mongolia can provide daily, 5-day, 10-day, monthly, and seasonal monitoring using over 40 drought composite methods with spatial variation and temporal dynamics. Mongolian technicians can fully operate the system on their own, monitor drought by themselves, and disseminate drought information to stakeholders throughout the country.[27] The outputs that the NRSC is producing, based on the DroughtWatch system, include real-time drought monitoring for disaster prevention and mitigation departments in Mongolia, servicing the Ministry of Nature, Environment and Tourism and the Ministry of Food, Agriculture and Light Industry and dissemination to local meteorological departments through an internal network. IRIMHE continues to conduct joint research with AIR to expand the system for dzud monitoring.[28]

c. India's Regional Drought Mechanism service node that supports drought monitoring in Sri Lanka

Under the Regional Drought Mechanism of ESCAP, India offered technical support to Sri Lanka on agricultural drought monitoring. Dedicated software called 'Drought Monitoring System-Sri Lanka (DMS-SL)' was conceptualized, developed and

[27] Information and Research Institute of Meteorology, Hydrology and Environment (IRIMHE). Available at http://irimhe.namem.gov.mn and www.eic.mn

[28] For example, a dzud or extreme weather event causing livestock mortality, due to the summer drought and subsequent harsh winter conditions, led to the death of over 7.5 million livestock, more than 17 per cent of livestock in the country in 2010. See United Nations. Office for Outer Space Affairs (OOSA), "Satellite-based system to monitor droughts/dzuds handed over to Mongolia", new and press release, 2 October 2018. Available at https://reliefweb.int/report/mongolia/satellite-based-system-monitor-droughtsdzuds-handed-over-mongolia

operationalized in Sri Lanka. This software package provides tools for automated analysis of satellite data and was provided to Sri Lanka and Myanmar along with training of their officials during 2015 and 2018, respectively. This process allows officials in Sri Lanka to understand the drought monitoring options, select and take forward the most important elements of the software and its approaches in order to incorporate it into drought monitoring plans and procedures.

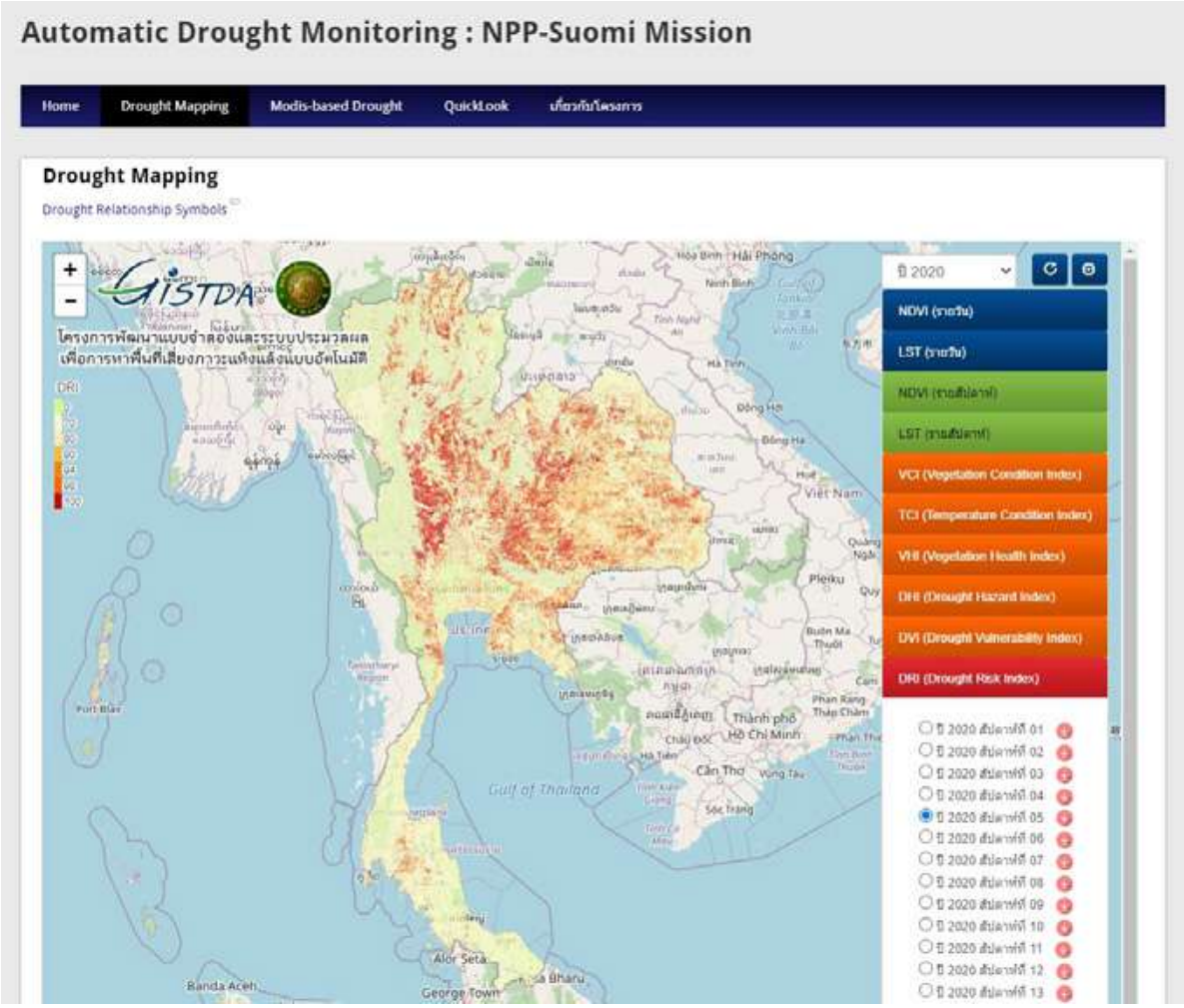
In India, drought monitoring and assessment practices by its states are streamlined according to the Ministry of Agriculture's National Drought Manual. The guidelines of the manual strongly recommended the use of multiple indicators representing weather, soil moisture, hydrology and crop status. The states adopted the manual, and thus satellite data analysis has become part of the drought monitoring and assessment mechanism. Through the Government of India's Department of Agriculture and Cooperation and Farmers Welfare, within the Ministry of Agriculture and Farmers Welfare, the National Agricultural Drought Assessment and Monitoring System (NADAMS) has been developed.[29] This system provides near real-time information on the prevalence, severity level and persistence of agricultural drought at multiple scales, including the state, district, and sub-district level. The monitoring system covers 14 states, focusing predominantly on agriculture-based regions prone to drought situations.

d. Drought monitoring in Thailand using space technology and geo-informatics

Thailand experiences annual drought, causing water shortages for domestic consumption and agriculture.

[29] Farmers' Portal, "National Agricultural Drought Assessment and Monitoring System (NADAMS)". Available at https://farmer.gov.in/nadams.aspx

Figure 3.17 GISTDA Thailand Drought Monitoring System



Source: GISTDA, Automatic Drought Monitoring: NPP-Suomi. Available at http://droughtv2.gistda.or.th/?q=content/drought-mapping
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

This causes both direct and indirect economic and social impacts. Therefore, Geo-Informatics and Space Technology Development Agency (GISTDA) of Thailand uses space technology applications and geo-informatics to monitor and assess areas, throughout the country, that are currently experiencing and are at risk of drought in order to provide input for efficient and continuous daily planning and management. GISTDA develops models and satellite image data processing systems, together with other relevant geo-informatics to assess three types of drought risk areas. The results include an indication of drought-affected areas from satellite imagery (Hazard assessment), exposure assessment of areas to assess vulnerable areas (Vulnerability assessment) and identification of dry risk areas (Risk assessment) to support management so as to reduce the risk of natural disasters (Risk reduction). This is in accordance with the 20-year national strategy (2017-2036), which is the National Water Master Plan for national development, to achieve the SDGs of Thailand. GISTDA provides quick access to data and

Box 4 Regional Drought and Crop Yield Information System

SERVIR-Mekong is an 8-year (2014-2022) joint initiative between the U.S. Agency for International Development (USAID) and the National Aeronautics and Space Administration (NASA) and is implemented by the Asian Disaster Preparedness Center (ADPC). The Regional Drought and Crop Yield Information System (RDCYIS) was developed as a direct response to serve the needs of the Lower Mekong countries for a real-time drought monitoring and forecasting system.

The overall system of RDCYIS,[a] is an integrated web-based information system intended to (1) improve the operational, technological, and institutional capabilities to prepare for and respond to droughts in the Lower Mekong region; (2) support local decision makers in drought monitoring, analysis, and forecasting; (3) provide policymakers and growers with current and forecast drought indices to facilitate decision-making within the current growing season; and (4) provide ecological and financial forecasting information to inform seasonal cropping decisions.

The RDCYIS is fully open to the public who not only can access data through the online interface, but can also download and use the data for their information and analytical research. The RDCYIS has now been customized both at the regional as well as at the national levels. The Mekong River Commission (MRC), for instance, has been using SERVIR-Mekong satellite imageries to produce weekly and monthly drought indices, which is made available in the form of bulletins to the line ministries of MRC Member States so that advance information reaches the decision makers and the farmers at the appropriate time. All this information can be accessed through the MRC Drought Portal.[b]

The MRC Drought Management Strategy 2020-2025 considered RDCYIS as a strategic focus with the aim to further strengthen MRC's drought forecasting and early warning by customizing the Regional Hydrologic Extreme Assessment System (RHEAS) model of the RDCYIS to develop a MRC stand-alone drought forecasting system.[c]

At the national level, Viet Nam and Cambodia have customized versions of RDCYIS for drought monitoring, forecasting and decision-making. In Viet Nam, with the technical support from SERVIR-Mekong, the Viet Nam Academy of Water Resources (VAWR), under Ministry of Agriculture and Rural Development (MARD), calibrated and customized the RDCYIS which is now been used for monitoring and forecasting drought conditions in South and South-Central Viet Nam.[d] VAWR is using this drought information in their monthly drought bulletins, which is then disseminated locally through the Department of Agriculture and Rural Development (DARD) informing the farmers of the prevailing drought conditions.

In Cambodia, ADPC together with the Food and Agriculture Organization (FAO) has provided the technical support to the Ministry of Agriculture, Forestry and Fishery (MAFF) in customizing the RDCYIS into a national

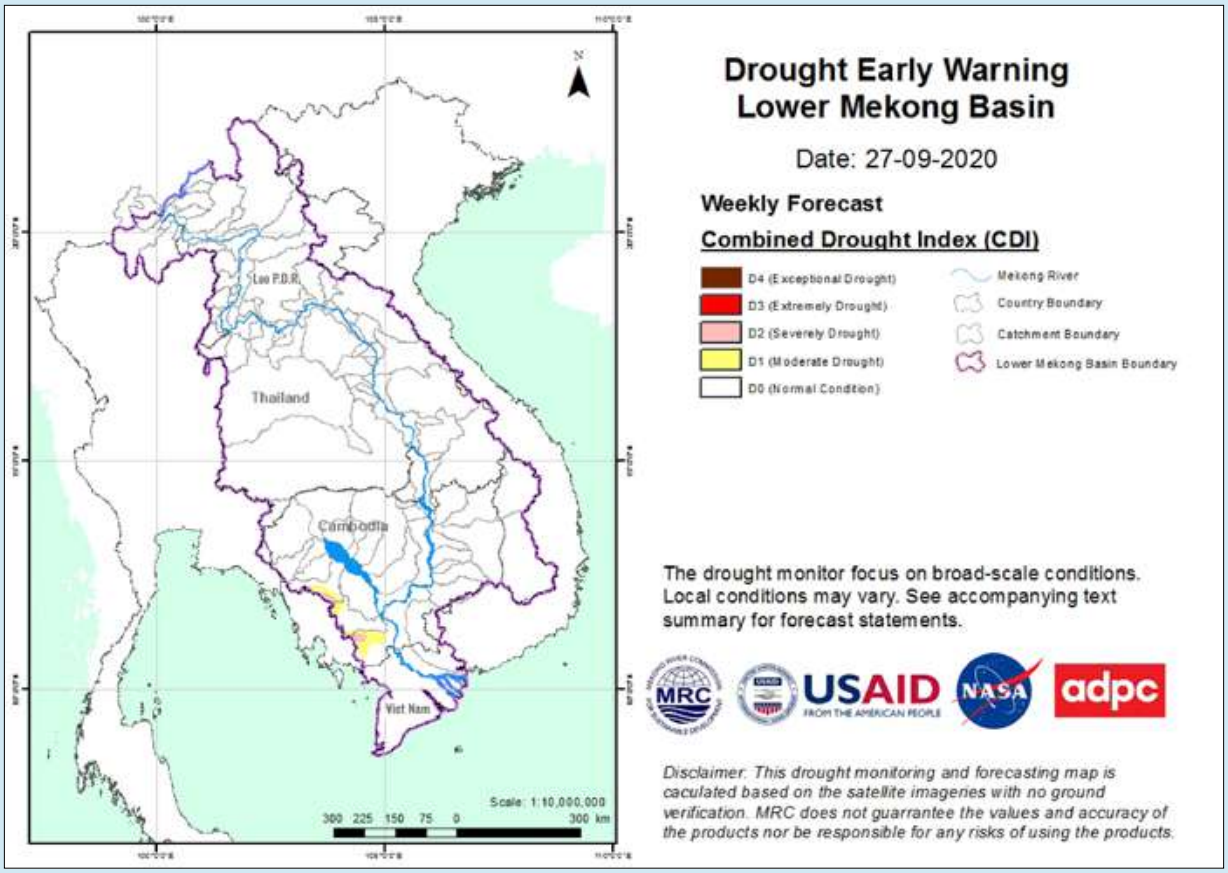
platform called the "Cambodia Drought Information System (CDIS).[e] In addition, ADPC supported the World Food Programme (WFP) in integrating drought information into the WFP's PRISM platform, which informs the National Committee for Disaster Management and its provincial counterparts of on-going disasters in Cambodia.

Capacity-Building

With the deployment of RDCYIS in Viet Nam, Cambodia and the MRC, SERVIR-Mekong ensured the institutional capacity to effectively use such tools through rigorous training and capacity-building programmes. The training and capacity-building programmes are held at the technical level, in order to ensure better uptake among the participants about the tools itself and its functionalities, both at the front- and back-end. Regular awareness and dissemination workshops bring together decision makers to update them about the usability of these tools for decision-making purposes.

SERVIR-Mekong is also providing technical support, in collaboration with ESCAP, to enhance the institutional capacity of its Member States on strengthening drought monitoring and early warning in Central Asia, where ESCAP is implementing a project on setting up a Central Asia Drought Information System (CADIS), in Kyrgyzstan. SERVIR-Mekong has also provided training support to ESCAP in Cambodia for enhancing the use of Earth observation data for drought monitoring and early warning.

Figure 3.18 Example of drought early warning map produced through the Mekong River Commission (MRC)



Source: Mekong River Commission (MRC), "Drought Early Warning Lower Mekong Basin", Available at http://droughtforecast.mrcmekong.org/maps
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

[a] USAID, NASA, ADPC, "Regional Drought and Crop Yield Information System". Available at https://rdcyis-servir.adpc.net/map
[b] Mekong River Comission (MRC), "Drought Early Warning Lower Mekong Basin". Available at http://droughtforecast.mrcmekong.org/maps
[c] Mekong River Commission (MRC), "Drought Management Strategy for the Lower Mekong Basin, 2020 – 2025". Available at http://www.mrcmekong.org/assets/Publications/MRC-DMS-2020-2025-Fourth-draft-V3.0-for-web_SM.pdf
[d] Viet Nam Drought Portal. Available at http://vndroughtportal.com/
[e] Ministry of Agricultural, Forestry and Fisheries, "Cambodia Drought Information System". Available at https://cdis-fao.adpc.net/

analysis to relevant agencies and the public through various portals, including: Government Emergency Situation Analysis System (PMOC),[30] the website for drought monitoring from the drought index,[31] drought tracking system website report,[32] and monitoring the situation of small water resources.[33]

During the international drought management capacity-building activities, organized by ESCAP and GISTDA, Cambodia, the Lao People's Democratic Republic and Myanmar requested an expansion of the GISTDA drought and crop monitoring platform to cover their countries. The process of implementing this under the Regional Drought Mechanism is under development.

Conclusion

The Sendai Framework for Disaster Risk Reduction (SFDRR), 2015–2030, presents a shift from disaster management to disaster risk management. The SFDRR priority 1 "understanding disaster risk" is driven by the lens of science, technology and innovations. The trends, as discussed above, highlight that various dimensions of multi-hazards, the spatial extent of exposure and risk knowledge are addressed using space applications. Large scale operationalization of space applications is the key to implement policies and practices for disaster risk management based on an understanding of disaster risk in all its dimensions of vulnerability, coping capacity, exposure, nature of hazard and environmental setting.

The examples discussed in this chapter, highlight the wide range of areas where countries in the region are leveraging space applications for disaster risk reduction and resilience. The cross-cutting, and cross boundary impacts of disasters in Asia and the Pacific require fast-paced data access, analysis, and cooperation. The variety of examples from countries around the region show the importance that space-derived information, its analysis and visualization, has for the decision-making processes for the disaster resilience cycle. The collaboration and partnerships among countries within the region also show how Member States can come together to build capacity and share knowledge.

These examples, spanning a variety of practices, demonstrate that the first phase of implementation of the Plan of Action is on track to address many of the sub-themes under disaster risk reduction and resilience. This is especially important for the region, as disasters impact many countries and building capacity is vital to future sustainable development.

[30] GISTDA, "Emergency Situation Analysis Report System –Prototype. Available at http://gistdaportal.gistda.or.th/pmoc/nusais/

[31] GISTDA Drought Portal, "Automatic Drought Monitoring". Available at http://droughtv2.gistda.or.th

[32] GISTDA, "Thailand Drought Monitoring System". Available at http://drought.gistda.or.th/

[33] GISTDA, "System for monitoring water sources". Available at https://smallwater.gistda.or.th/

Chapter 4.

Space for socioeconomic development - Highlights for natural resource management

As the human population and its impact on ecosystems and natural resource use grows, sustainable natural resource management (NRM) is becoming increasingly important.[1] The Asia-Pacific region consumes more than half of the world's natural resources,[2] and the evidence is overwhelming that the region is not on track to achieve the sustainable use of the planet's shared natural resources (such as water, soil, land and air).[3] Improving natural resource management and protecting the ecosystems from the local to the global scale is vital for sustainable development and progress must be accelerated to achieve the priority goals in the Regional

[1] Bertram Ostendorf, "Overview: Spatial information and indicators for sustainable management of natural resources", Ecological Indicators, vol. 11, No. 1 (January 2011). Available at https://doi.org/10.1016/j.ecolind.2010.10.003

[2] United Nations Environment Programme (UNEP), "Global Resources Outlook 2019: Natural Resources for the Future We Want - Summary for Policymakers, 2019". Available at https://wedocs.unep.org/bitstream/handle/20.500.11822/27518/GRO_2019_SPM_EN.pdf?sequence=1&isAllowed=y

[3] Asia and the Pacific SDG Progress Report (United Nations publication, Sales No. E.20.II.F.10). Available at

Roadmap for implementing the 2030 Agenda for Sustainable Development in Asia and the Pacific.[4] Space applications offer valuable data, information and solutions to support sustainable resource management and conservation. For example, remotely sensed data provide an unparalleled, high resolution view of the Earth for monitoring agriculture, marine resources, hydrology, ecology, and land use.

The environmental impacts of human activity make resource management increasingly complicated; as our understanding of complex natural processes increases, so does our need for information at appropriate spatial and temporal scales in order to overcome the limitations in evidence-based NRM decision-making.[5] Thus, space-derived information, its analysis and visualization, offer increasingly important input into the decision-making processes for NRM. For example, space applications can provide inputs for monitoring the environmental impacts of human activity, geomorphology and changes in land use, or weather patterns and their effects on agriculture and livelihoods. Space and geospatial technology can also fuse together spatial data, such as water levels in rivers, with non-spatial data, such as rainfall, to help prioritize work and develop action plans in managing water supply.

The proposed actions on space applications for NRM developed by countries in the region through the Asia-Pacific Plan of Action on Space Applications for Sustainable Development (2018–2030) (Plan of Action),[6] will support implementing many of the SDGs, as shown below. Many activities have crosscutting benefits to other sectors, such as water use, sustainable marine and coastal ecosystems, forests resources, urban planning, land degradation and desertification. Progress in these areas is ongoing and this section provides an overview of the regional status in the priority theme of NRM. This highlights country practices and experiences in NRM, with a focus on food security, ecosystem resilience, and marine and coastal monitoring, highlighting integration into national planning and policy, where possible.[7]

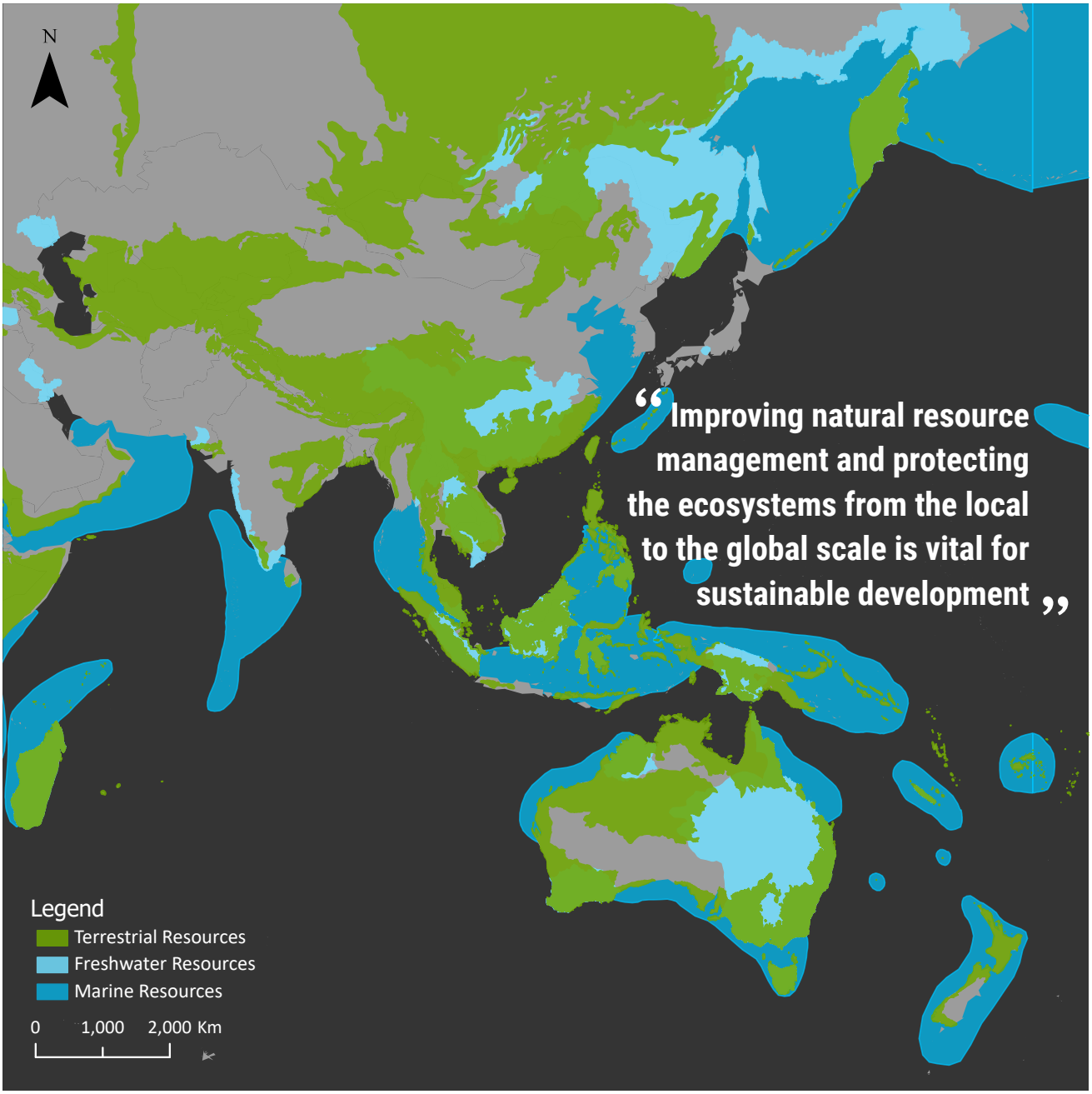
[4] ESCAP, "Regional Roadmap for implementing the 2030 Agenda for Sustainable Development in Asia and the Pacific", 2017. Available at https://www.unescap.org/sites/default/files/publications/SDGs-Regional-Roadmap.pdf

[5] Sylvie Durrieu, and Ross F. Nelson, "Earth observation from space - The issue of environmental sustainability", Space Policy, vol. 29, No. 4 (November 2013). Available at https://www.sciencedirect.com/science/article/pii/S0265964613000659 And, Bertram Ostendorf, "Overview: Spatial information and indicators for sustainable management of natural resources", Ecological Indicators, vol. 11, No. 1 (January 2011). Available at https://doi.org/10.1016/j.ecolind.2010.10.003

[6] ESCAP/75/10/Add.2; See Asia-Pacific Plan of Action on Space Applications for Sustainable Development (2018–2030). Available at https://www.unescap.org/commission/75/document/E75_10A2E.pdf

[7] Ibid.

Ecosystem service location map showing terrestrial, fresh water and marine ecosystems within the Asia-Pacific region



Map developed by ESCAP. Data Source: WWF Global 200 (https://www.worldwildlife.org/publications/global-200) and Olson, D. M., Dinerstein, E. 2002. The Global 200: Priority ecoregions for global conservation. Annals of the Missouri Botanical Garden 89(2):199-224.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

1. Agricultural monitoring and planning

Agriculture and food systems are not only critical to the livelihoods of many people in the region, but serve as an economic driver in multiple countries in Asia and the Pacific. They function as the sole source of sustenance and income, especially in poor and vulnerable communities that are characterized by stark inequalities. For example, gender inequalities exist in the form of women's limited access to assets, knowledge, information and support in agricultural production.[8, 9] Furthermore, a growing population and changing diets means that food production will need to increase 50 per cent by 2030 and 70 per cent by 2050, and yet the region is already reaching

[8] Food and Agriculture Organization of the United Nations (FAO), Agri-Gender Statistic Toolkit, Ankara, 2016. Available at http://www.fao.org/3/a-i5769e.pdf

[9] World Bank, "Gender issues in monitoring and evaluation in agriculture", Working Paper, No. 73819 (Washington, D.C., 2012). Available at http://documents.worldbank.org/curated/en/463521468183861258/Gender-issues-in-monitoring-and-evaluation-in-agriculture

its limit of available arable land, and may potentially begin losing agricultural land due to degradation and urbanization.[10] In addition to this, the supply chain, economic and social impacts of climate change and the COVID-19 pandemic add further strain to food security, which is already threatened by a myriad of other factors.[11] According to the World Food Programme (WFP), the number of people facing food insecurity could nearly double in 2020 to 265 million due to the economic consequences of COVID-19.[12]

A range of strategies will be needed to improve the quality and productivity of food production while maintaining the integrity of the ecosystems that we depend upon for food, clean water and air, soil renewal, pest control and more. The effective use of geospatial data and Earth observation information, in combination with data gathered in the field, provides tools that enhance the collection, storage, analysis and dissemination of food security information and allows for more accurate environmental and social impact assessments and more informed decision-making at all levels.[13]

Remote sensing systems using readily available information from environmental monitoring satellites, can regularly monitor the condition of crops over large to localized areas to provide early warning on vegetation stress due to drought, flooding or pests.[14] For instance, precision agriculture is an important tool through which such technologies are assisting farmers in sustainable intensification of agriculture. Furthermore, through building the capacity of agricultural experts to monitor and interpret satellite information, it is possible to directly monitor specific crops in order to enhance their productivity.[15]

International efforts to leverage geospatial information for food security are already proving extremely important. For example, the Group on Earth Observations Global Agricultural Monitoring Initiative (GEOGLAM) helps to increase market transparency and improve food security by producing and disseminating relevant, timely, and actionable information on agricultural conditions and outlooks of production at national, regional, and global scales by strengthening the international community's capacity to utilize coordinated, comprehensive, and sustained Earth observations.[16] Many countries in the Asia-Pacific region already have experience developing and implementing tools, approaches, and systems to leverage space applications for enhanced food security. The following examples will explore the practices and processes and dive deeper into understanding the enabling conditions for successful implementation.

a. Japan: Asia-Pacific Regional Space Agency Forum Space Applications for Environment activity (SAFE)

Space Applications for Environment (SAFE) is a voluntary initiative to encourage long-term environmental monitoring to understand environmental changes. One of the major projects initiated by SAFE is its agrometeorology project. It is designed to reduce agriculture disaster risk through the provision of crop outlook information, using Earth observation satellite data and agricultural information for food security. JASMIN, an agrometeorology information provision activity, that uses the JAXA agrometeorology system, has been implemented under the SAFE initiative and GEOGLAM. JASMIN is useful for decision-making on food security and drought monitoring. In the future, the SAFE agrometeorology plans to expand to South Asia through cooperation with India and other SAFE project participating organizations.

b. Bangladesh: Satellite imagery and data to support the agricultural sector

For better national food security, the Bangladesh Space Research and Remote Sensing Organization (SPARRSO)[17] regularly uses satellite images and data

[10] Piero Conforti, ed., "Looking Ahead in World Food and Agriculture Perspectives to 2050", Food and Agriculture Organization of the United Nations (FAO), 2011.

[11] UN News, "Keep critical food supply chains operating to save lives during COVID-19, urges new UN-backed report", 12 April 2020. Available at https://news.un.org/en/story/2020/04/1062192

[12] "Global hunger could double due to COVID-19 blow: U.N.", Reuters, (Geneva), 21 April 2020. Available at https://www.reuters.com/article/us-health-coronavirus-un-food/global-hunger-could-double-due-to-covid-19-blow-u-n-idUSKBN22313U

[13] United Nations Office for Outer Space Affairs, "Space for agriculture development and food security - Special report of UN-Space on the use of space technology within the United Nations system for agriculture development and food security", 2013. A/AC.105/1042. Available at

[14] See example of Thailand's crop monitoring system in Chapter 4, Section 1c

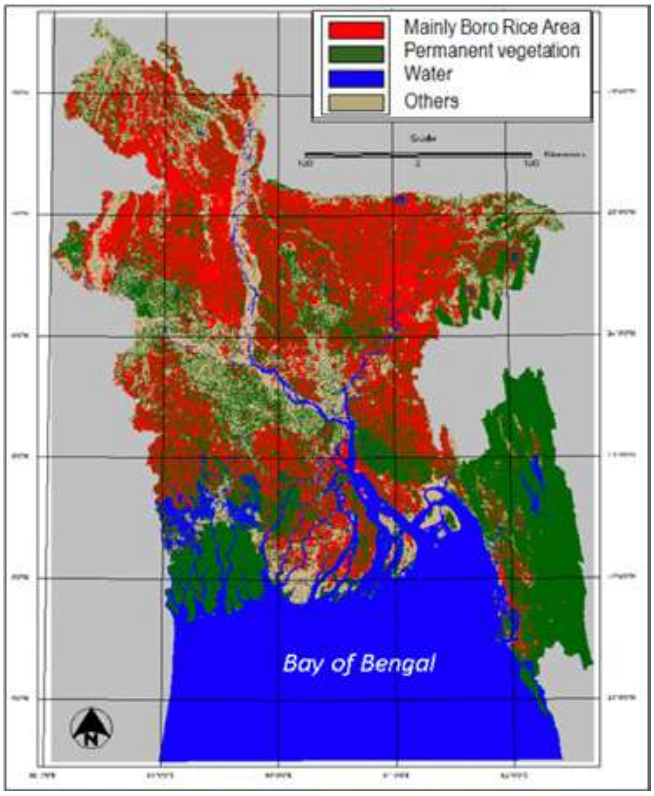
[15] See example of CropWatch cloud in Chapter 4, Box 1.

[16] Global Agricultural Monitoring (GEOGLAM), "About GEOGLAM". Available at http://earthobservations.org/geoglam.php

[17] Bangladesh Space Research and Remote Sensing Organization (SPARRSO). Available at http://www.sparrso.gov.bd/

to support the agricultural sector in Bangladesh, with a focus on major agricultural crops, specifically rice. Time-series satellite remote sensing data, covering a period of January to December, is acquired at the country scale to estimate the area coverage of major agricultural crops. The methodological approach consists of remote sensing radiometric analysis of temporal and spatial dynamics of crop radiative responses, supported by GIS. The Boro and Aman rice area coverage maps are supplied to the Bangladesh Bureau of Statistics (BBS) for the final calculation and determining of appropriate import policies for rice (Figure 4.1).

Figure 4.1 Satellite-image map of Boro rice area, in Bangladesh, 2019



Source: SPARRSO
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

c. Thailand: Managing agricultural areas through space applications and GISTDA initiatives

The Land Development Department of Thailand (LDD),[18] uses space applications to support the country's agricultural sector in many ways, including surveying soil classification for agricultural planning, and for agricultural land census. Surveying soil classification for agricultural planning uses satellite images in combination with aerial imagery.[19] This allows soil classification throughout Thailand by Soil Group and Soil Series to be used for agricultural planning including the soil guide,[20] and on FARM platforms,[21] which is perfectly aligned with the Plan of Action to share knowledge on developing soil maps for ecosystem management. Much in the same way, the agricultural land census uses satellite images, in combination with aerial imagery, to support agricultural policy and planning. This allows decision makers to better understand the true cost of agricultural production and to be able to appropriately forecast agricultural production.[22] The main challenges for both soil classification and agricultural land census include the high expense of satellite image data and high definition aerial imagery and the lack of staff needed to survey the whole country.

In line with Thailand's *National Strategy 2018-2037* mandate on smart farming, Geo-Informatics and Space Technology Development Agency (GISTDA) uses geographic and spatial technology to monitor and manage agricultural areas, especially the major economic crop areas of the country, such as rice, corn, cassava, and sugarcane. Satellite data is used to track all four types of cultivated crops in 2-week intervals covering the whole country, report the situation of cultivated land, from planting to harvest, including the estimated harvest date. This allows management and production in each area to become more efficient.

Since 2014, GISTDA has been using satellite data, both from passive and active sensors for the semi-automatic interpretation of planting areas, for checking and assessing the accuracy of analysis results, in cooperation with experts from partner agencies of the Ministry of Agriculture and Cooperatives, such as the Department of Rice, the Department of Agricultural Extension Office of Agricultural Economics and the

[18] Land Development Department, Thailand. Available at http://www.ldd.go.th/

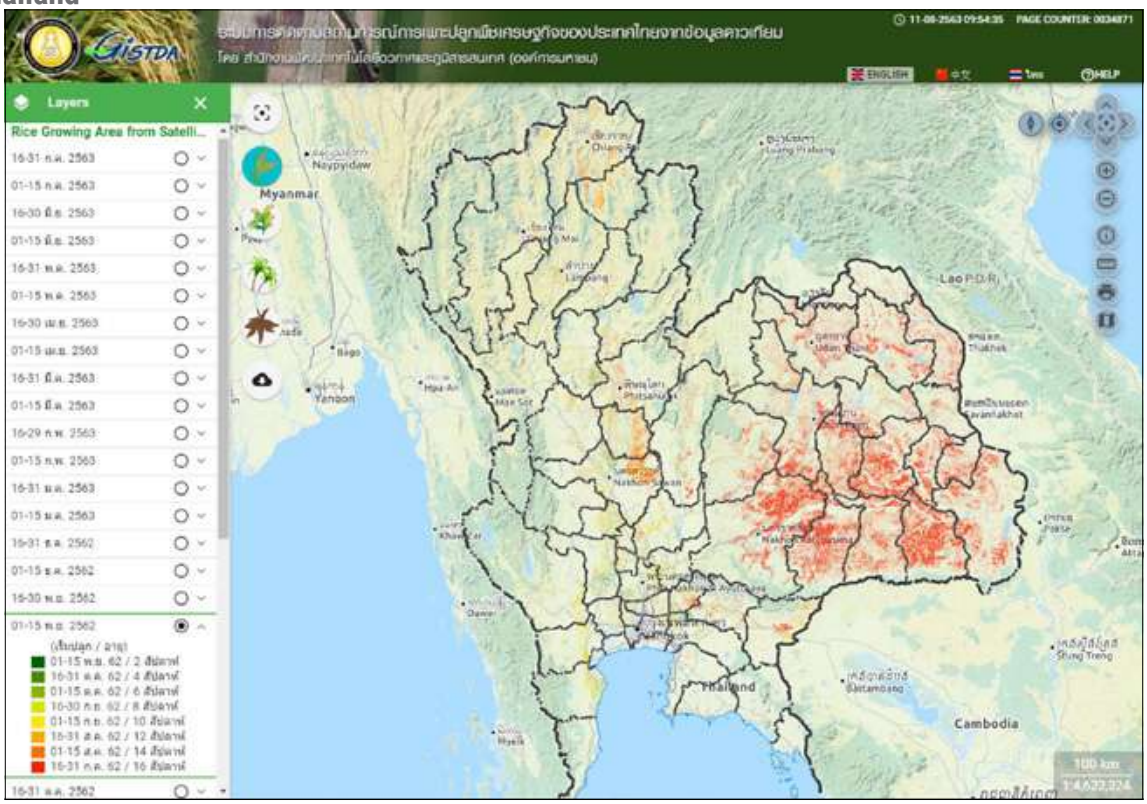
[19] Land Development Department, Thailand, Soil series visualisation system. Available at http://eis.ldd.go.th/lddeis/SoilView.aspx

[20] Land Development Department, Land and fertilisation information system, LDD Soil Guide. Available at http://lddsoilguide.ldd.go.th/soilguide/#/app/map

[21] Land Development Department, Land and fertilisation information system. Available at https://lddonfarm.ldd.go.th/lddonfarm/main

[22] See the LDD Zoning application. Available at https://lddzoning.ldd.go.th/webzoning/page.aspx

Figure 4.2 The GISTDA Rice Monitoring System and online portal showing crop conditions in Thailand



Source: GISTDA
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Royal Irrigation Department.[23] This allows monitoring the status or stage of plant growth, including the estimated harvest date and yield of each plant. Users can access and download information from the monitoring system about the condition of the crop from satellite data in the form of reports, maps, and GIS data layers.[24] At the policy level, relevant departments can use this information as an additional analysis support tool for specific applications, such as monitoring rice cultivation during drought in order to be able to announce the delay of rice cultivation, managing water analysis of corn plantations in highland and forest areas, providing solutions to high-risk pesticide use, planning and tracking cultivated land in lowland areas and analysing planting areas together with topographic data for flood and drought areas for the management of cultivation and disaster preparedness, etc. In addition, GISTDA provides data from the system to the comprehensive rice information working group, which is one of the national policy committees for formulating appropriate and up to date spatial agricultural policy.

The Centre of Agricultural Information, Office of Agricultural Economics Land Development Department under Ministry of Agriculture and Cooperatives classified and validated the cash crops of Thailand, such as rice in both the wet and dry season, cassava, maize, pineapple, oil palm, and para rubber, pineapple and para-rubber. With the use of survey techniques and statistic methods, and in combination with Google Earth Engine and high-resolution imagery, the accuracy was increased while the agricultural areas were validated by collecting ground truthing data. This agricultural information is necessary for supporting agricultural decision-making and planning. The main obstacles were cloud cover problems, especially in the wet season and especially apparent in time-series analysis. Therefore, GISTDA hopes to use another source of satellite data, such as the SAR (Synthetic Aperture Radar) sensor, however, this SAR technique requires different pre-processing and analysis processes and additional staff capacity development. Furthermore, the project to launch THEOS-2 is an excellent opportunity and challenge to derive new satellite data for the interpretation of agricultural areas, which will be integrated into other projects, such as the estimation of crop yield or crop phenology.

[23] Including data from Landsat-8 satellites, TERRA satellites and AQUA and from MODIS (Moderate Resolution Imaging Spectroradiometer) system and from active sensors: data from Radarsat-2 satellites and Sentinel-1 satellites.

[24] GISTDA. Available at www.ecoplant.gistda.or.th

Box 5 Cambodia: CropWatch Cloud brings universal access and easy-to-use templates

CropWatch Cloud is a cloud-based crop monitoring platform providing an agroclimatic, agronomic information service, with a unique solution for developing countries aspiring to conduct their own crop monitoring, in order to achieve food security.[a] The fundamental principle of the CropWatch Cloud is to move the user from the current paradigm of data and tools to the paradigm of a cloud service available to end users in the global food security community, anytime and anywhere. The components of the cloud-based platform allow users to implement crop monitoring to explore agricultural monitoring results in the form of vector, raster, dynamic charts and tables, to provide online agricultural information services in a near real-time manner. Including agroclimatic, agronomic and food production situation indicators, without the need to analyse the original data. Additionally, users can access the joint analysis platform, involved in the analysis for a global or country report, or conduct independent reports for their own countries, provinces, or even districts.

The Institute of Remote Sensing and Digital Earth (RADI), Chinese Academy of Sciences, in collaboration with the Department of Planning and Statistics (DPS) in the Ministry of Agriculture Forestry and Fisheries (MAFF), Government of Cambodia, along with relevant ministries and departments in Myanmar, Thailand and Viet Nam and in ESCAP are implementing the project in the hope to directly benefit government officials, representatives and practitioners in Cambodia through capacity-building activities and as users of the upgraded systems. For example, officials in the DPS can now use geospatial data applications to monitor agricultural crops in relation to identifying planting areas, crop development conditions, potential climate change risks and options for timely interventions. This would ultimately and indirectly contribute to strengthening food security and improve the livelihoods of people in the participating countries, at the national and provincial levels.

CropWatch Cloud offers a unique opportunity for Cambodia to work on crop monitoring without investment on storage and computational resource. For example, reports on crop condition assessment for Cambodia, at both the national and regional level, were jointly undertaken by representatives from the MAFF and the CropWatch team.[b] The access to the data and analysis platform are open and easy to use, however this does not negate the need to invest in training and in country-level data inputs for validation. Training sessions on cloud-based crop monitoring system (CropWatch Cloud) and associated ICT applications were organized in Beijing, Bangkok, and Phnom Penh. The trainings enhanced the capacity of MAFF to utilize geospatial information and integrate it with data related to agriculture and water management to help customize the CropWatch Cloud for Cambodian conditions.

Figure 4.3 Joint field work to collect thousands of data points in Cambodian rice fields in December 2019

Source: The Institute of Remote Sensing and Digital Earth (RADI), 2019

Subsequently, joint field work was carried out in Cambodia, in December 2019, and thousands of in-situ data points were collected over major rice producing regions. The CropWatch Cloud and capacity-building process has not only assisted technicians in Cambodia and improved their monitoring ability, but also promoted ownership and innovation on agriculture monitoring.

[a] CropWatch. Available at http://cloud.cropwatch.com.cn

[b] CropWatch, "November 2019 CropWatch Bulletin: Cambodia main producing and exporting countries". Available at http://cloud.cropwatch.com.cn/report/show?id=134&section_id=20259. Crop condition assessment reports are available on the CropWatch Cloud platform

d. Malaysia: Precision agriculture

Precision agriculture enables more efficient decision-making based on availability of site-specific information. It can help achieve higher productivity by identifying variations in soil characteristics and moisture content, facilitating improved assessment of pest and disease attack, and enabling necessary remedial action. It promotes a more efficient use of fertilizers and pesticides, and helps attain cost savings on both material and labour inputs, while reducing the negative fallout of agricultural operations on the health of farmers and the environment. In Malaysia, for instance, in order to reduce the use of fertilizers in paddy production, a precision agriculture technology package was demonstrated by the Malaysian Agricultural Research and Development Institute to local farmers in three granary areas. The technology package involved the use of unmanned aerial vehicles (UAVs) to help develop prescription maps, that were used by a variable rate applicator.[25] Subsequently, 400 respondents expressed interest in implementing the demonstrated technology with the majority of them noting that the benefits outweighed the costs.[26] The grouping of small-scale farmers helps maximize the efficiency of precision agriculture.

There are a number of constraints on the wider adoption of precision agriculture and related ICT-enabled mechanization technologies, such as autonomous equipment and precision irrigation in the Asia-Pacific region. About 90 per cent of the world's small farms (less than 2 hectares) are in this region while the average size of land holdings in Asia is only about 1 hectare. Often, these small holdings are further scattered into smaller plots across different locations. Many of these plots cannot offer access to large-sized farm machinery or cannot provide the scale needed to justify the cost of technology upgrades. Smallholders in the region also have very limited investment capacity. This has led to a situation where smallholders are unable to adequately leverage the benefits of precision agriculture or other space and geospatial information applications.

In order to enable small and marginal farmers to leverage their benefits, service provision for technologies based on space and geospatial information applications should be encouraged so that farmers can avail them on an as-needed basis, thus avoiding significant investment cost. At the same time, upgradation of digital infrastructure and connectivity in rural areas must be promoted to provide better access to such technologies. Finally, public investment in capacity-building for farmers as well as service providers must be enhanced with due attention to the needs of rural women and elderly workers.

2. Water management

Freshwater accounts for only around 2 per cent of the global water volume, but its use has increased by a factor of six over the past century and continues to steadily grow,[27] due to increasing population, economic development and inefficient consumption patterns. Global water demand is estimated to increase by 55 per cent between 2000 and 2050,[28] with other studies indicating a likely 40 per cent water deficit by 2030.[29, 30]

Freshwater is generally stored in surface waters, such as rivers and lakes; in the cryosphere as snow, glaciers and permafrost; biologically in plants and animals; geologically in the soil and groundwater; and in the atmosphere. Monitoring and accounting for this cycle of water is an important factor in water management, especially to meet the growing demand, and in some areas the present scarcity. The Earth's climate and the terrestrial water cycle is closely linked in a complex relationship which dictates the normal seasonal availability of rainfall, flow of rivers and recharge of groundwater. Climate change is projected to impact this cycle severely for some regions, with increasing drought and loss of storage through glacial melt. Other areas face more frequent and/or severe climate

[25] A variable rate applicator allows for the automated application of farm inputs such as fertilizer to be applied at different rates across a field, without manually changing rate settings on equipment.

[26] Food and Fertilizer Technology for the Asian and Pacific Region, "Saving fertilizer in Malaysia's large-scale paddy production through precision farming", 9 July 2020. Available at https://ap.fftc.org.tw/article/2519

[27] UNESCO, UN-Water, "UN World Water Development Report 2020: Water and Climate Change", Paris. Available at https://www.unwater.org/publications/world-water-development-report-2020/

[28] OECD, "OECD Environmental Outlook to 2050: The Consequences of Inaction", Paris, OECD Publishing, 2020. Available at https://read.oecd-ilibrary.org/environment/oecd-environmental-outlook-to-2050_9789264122246-en#page2

[29] 2030 World Resources Group, "Charting our Water Future: Economic Frameworks to Inform Decision-making", 2009. Available at www.mckinsey.com/~/media/mckinsey/dotcom/client_service/sustainability/pdfs/charting%20our%20water%20future/charting_our_ water_future_full_report_.ashx.

[30] UNESCO, UN-Water, "United Nations World Water Development Report 2020: Water and Climate Change", Paris. Available at https://www.unwater.org/publications/world-water-development-report-2020/

events, such as cyclones and floods, which may damage infrastructure and result in loss of life and livelihoods.

Pollution, such as organic waste, pesticides and fertilizers, heavy metals, pathogens and other pollutants are also an increasing problem that limits the availability of clean water. Poor sanitation and wastewater treatment from municipalities and industry, along with the intensification of agriculture contribute to this increasing burden of pollution, which doubly impacts water resources that are becoming even scarcer.

Over the past decades, advances in geospatial applications, remote sensing and ICT are providing a greater volume and quality of information for water monitoring and modelling, which in turn provides better information for integrated water management. For instance, space applications can monitor trends in precipitation, evapotranspiration, snow and ice cover, runoff and storage of water. Techniques for monitoring parameters, such as turbidity, suspended solids, chlorophyll-a, dissolved organic matters and water surface temperature helps identify areas potentially affected by organic pollution.[31] Various AI-based techniques, models and machine learning algorithms are also being used to monitor and analyse water quality, availability and quantity.[32] Integrating and validating these technologies and processes with ground monitoring and national statistics are powerful tools for water resource management.

Space applications and technologies are already being utilised within the field of water management. An example of this is the Gravity Recovery and Climate Experiment satellite mission operated by NASA and the German Aerospace Center. This satellite was launched in 2002, and began recording information and changes on groundwater, ice mass and other large bodies of water through an analysis of the variations in gravity. Results indicate that polar and mountain ice mass loss has increased by 300 per cent since the satellite was launched. In addition, 13 of the 37 most significant land-based aquifers have undergone a critical loss of mass which is representative of water lost due to climate related change.[33] Additionally, many countries within the Asia-Pacific region are already utilising space applications and geospatial information to inform water management, especially for surface water mapping and management. Some of these techniques are highlighted below.

[31] UNESCO, IHP, The UNESCO-IHP IIWQ World Water Quality Portal – Whitepaper: International Initiative on Water Quality (IIWQ), 22 January 2018. Available at https://www.eomap.com/exchange/pdf/UNESCO_Information_Booklet_Water_Quality_Monitoring.pdf

[32] UNESCO, UN-Water, "United Nations World Water Development Report 2020: Water and Climate Change", Paris. Available at https://www.unwater.org/publications/world-water-development-report-2020/

[33] B. D. Tapley, and others, "Contributions of GRACE to understanding climate change", Nature Climate Change, vol. 5, No. 5 (1 April 2019), pp. 358–369. Available at doi.org/10.1038/s41558-019-0456-2.

a. Australia: Monitoring water in the Great Artesian Basin

In Australia, the Great Artesian Basin is one of the largest underground freshwater resources in the world, covering more than 1.7 million square kilometres. This water resource is vital for pastoral, agricultural and extractive industries and urban water supplies. To better understand the quantity and quality of this basin, the Australian Government commissioned Geoscience Australia to conduct a project to develop and evaluate new tools and techniques to assess the groundwater resources for better management. Covering the period from 2019 to 2022, the work will develop an evidence-based, low-cost, decision-making tool that monitors groundwater storage changes over time, in a timely manner, and identifies "hotspots" of increased demand or high priority. It will also test techniques, tools and information to improve the hydrogeological framework for assessing the water balance and identify data and knowledge gaps for further research. Data used will include Gravity Recovery and Climate Experiment and Interferometric Synthetic Aperture Radar (InSAR) satellite-based measurements to determine the change in the volume of groundwater in specific pilot areas over time. This will contribute to the Hydrogeological Atlas of the Great Artesian Basin, which also includes work from the CSIRO-led Great Artesian Basin Water Resource Assessment project.[34]

b. Philippines: Hydrologic Dataset using LiDAR surveys

Philippines developed the Philippine Hydrologic Dataset for Watershed using Light Detection and Ranging, commonly known as LiDAR surveys. These datasets have led to detailed maps of all water resources in Philippine watersheds, including hydrologic units, stream and river networks, dams, and other natural and man-made water features. This repository features calibrated spatial parameters which can be used for water balance analysis, hydrological modelling or other applications. Currently, Philippine Hydrologic Dataset is being used as reference and training datasets for irrigation networks by the Remote Assessment of Irrigation Networks project, which is funded by the Philippine Department of Budget and Management.

Zamboanga City and its surrounding areas in the Philippines has also established a groundwater resource management plan and monitoring system using automated, real-time monitoring of groundwater through various sensors, data logging and telemetry equipment. The equipment measures water quality and quantity, including salinity, total dissolved solids, conductivity and temperature, which allows the system to act as a decision support tool for the National Water Resources Board and the local governments.

c. Australia: Data Cube

The Australian Water Partnership recently supported eWater,[35] Geoscience Australia,[36] and the Australian Government Bureau of Meteorology,[37] to build an Open Data Cube for water management decision-making, in Cambodia, as part of the Regional Drought Mechanism. The project integrated three separate tools which had not previously been connected: Geoscience Australia's Open Data Cube technology,[38] (a ground-breaking way of cost-effectively storing, managing and processing large amounts of space-based information); streamflow forecasting tools;[39] and eWater Source which is Australia's National Hydrological Modelling Platform[40] (Figure 4.4).

The Data Cube was built to combine a wide range of space-based water information including rainfall, catchment boundaries and outputs, potential evapotranspiration and Standardised Precipitation-Evapotranspiration Index grids. Separately, the Bureau of Meteorology produced bias-corrected rainfall estimates and streamflow forecasts using

[34] Australian Government, Geoscience Australia, "Great Artesian Basin". Available at https://www.ga.gov.au/scientific-topics/water/groundwater/gab#heading-1

[35] The Australian Water Partnership, "eWater". Available at https://waterpartnership.org.au/partners/ewater-ltd/

[36] Australian Government, Geoscience Australia, "Applying geoscience to Australia's most important challenges", Available at http://www.ga.gov.au/

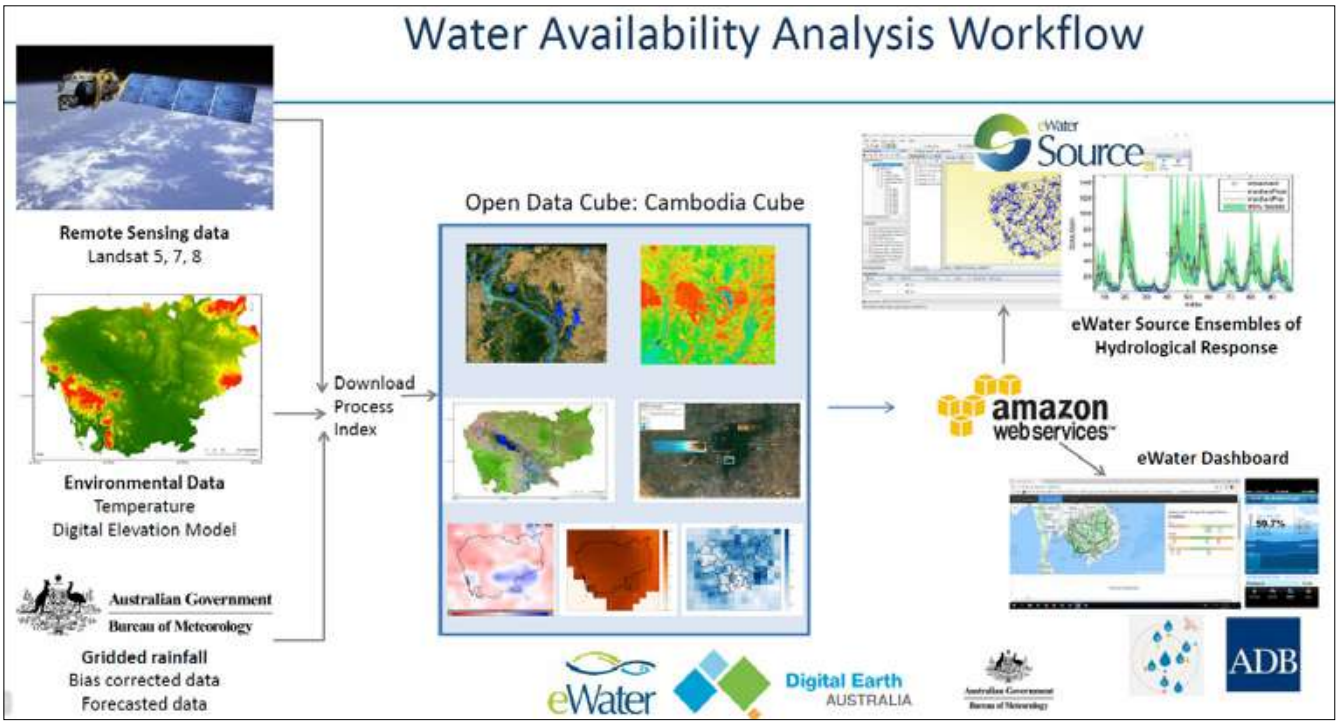
[37] Australian Government, Bureau of Meteorology. Available at http://www.bom.gov.au/

[38] Australian Government, Geoscience Australia, "Open Data Cube". Available at https://www.ga.gov.au/dea/odc

[39] Australian Government, Bureau of Meteorology, "Seasonal streamflow forecasting service launched". Available at http://www.bom.gov.au/water/news/article.php?id=16

[40] eWater, "eWater Source". Available at https://ewater.org.au/products/ewater-source/

Figure 4.4 Water Availability Analysis Workflow



Source: eWater Australia, " Piloting Australia's Water Tools to improve Drought Resilience in Cambodia –Support for the UN ESCAP Drought Mechanism", PowerPoint presentation, slide No. 5, 2018.

satellite rainfall estimates from the Tropical Rainfall Measuring Mission and created workflows to feed this information into the Cambodia Data Cube. It was then extracted, along with other space-based water information, to create a Source model to produce water balance and flow estimates. Estimates were produced at the catchment and basin level, and at seasonal and annual timescales.

The final part of the project saw the development of water availability products that can be offered as hydrological drought metrics as part of the Regional Drought Mechanism project. These products have been published on an online dashboard that can be accessed from a range of platforms, including smartphones.[41]

d. India: Water resource information system

The ISRO has also developed a national water resources information system called India-WRIS to provide a single portal for all water resources data and information in a geo-coded format, allowing users to search and analyse more comprehensive data for planning, development and integrated water resources management.[42]

The India National Information System for Climate and Environment Studies is a multi-institutional effort to compile a range of geophysical parameters and space-based information into one database accessible through the Bhuvan Portal (Figure 4.8).[43] The information pertaining to, for example, albedo, cloud properties, forest fire regimes, land cover, ocean colour, ozone, soil moisture, sea level pressure, ocean surface currents, snow cover, river discharge (runoff), total alkalinity and pCO2, is used for climate studies and impact assessments.

Under the South Asia Water Initiative administered by the World Bank, and supported by the United Kingdom, Australia and Norway, India has made use of the Ganga River Basin modelling suite to support integrated assessments of the hydrology, geohydrology, water resource management, water quality and ecology. The modelling tool covers the entire basin within India and the upper basin area located in Nepal and China. This model represents water resources at a level of detail suitable for developing scenarios to inform

[41] Australian Aid, "Integrating Australian water tools to better manage water scarcity", 22 August 2019. Available at https://waterpartnership.org.au/integrating-australian-water-tools-to-better-manage-water-scarcity/

[42] Government of India, Department of Space, Indian Space Research Organisation (ISRO), "India-WRIS". Available at https://www.isro.gov.in/earth-observation/india-wris

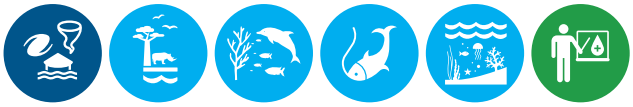
[43] Bhuvan, Indian Geo-Platform of ISRO. Available at https://bhuvan-app3.nrsc.gov.in/data/download/index.php

basin planning. It also permits River Basin Planning and Management schematization, allowing Indian officials to plan water use more efficiently.

3. Marine and coastal resource management

Marine and coastal areas are essential for economic activity and encompass a variety of valuable ecosystems, such as coral reefs and mangroves. Such areas can play an important role in supporting biodiversity, mitigating climate change, protecting against disasters and providing a raft of social and economic benefits. Beyond the monitoring of physical ocean characteristics for water management, meteorology and climate, important information can be assessed based on biological and ecological characteristics of these zones. The monitoring of marine and coastal environments can provide valuable data for natural resource management practices which in turn can help manage and protect the planet's oceans and coastal zones.

a. Coral reefs: Australia, India, Thailand



Coral reefs are important ecosystems for fisheries, provide tourism benefits and protect coastal areas against disasters, such as storm surges. Coral bleaching is caused by algae being expelled from the coral tissue when the water is too warm. This alga is the primary source of food for the coral and its loss puts the organism under greater stress, potentially leading to coral death.

In 2016, the Great Barrier Reef, in Australia, listed as a World Heritage site, experienced a massive bleaching event. A study using aerial and underwater surveys, combined with satellite derived sea surface temperature data, found that cumulative damage from three major bleaching events in 1998, 2002 and 2016 covered almost the entire 344,000 square kilometres of the reef.[44]

Sea surface temperature fluctuations are the result of many factors, but generally align with El Niño/La Niña events which will become more extreme with climate change. Unfortunately, though some coral will recover from the bleaching events, when corals die the recovery time for the fastest growing coral species is still 10 to 15 years, whereas the replacement for long established colonies will take many decades. For this reason, many countries have begun monitoring coral bleaching and reef health. Remote sensing techniques using the sea surface temperature provides a quick, broad way to assess the risk of coral reef bleaching. Australia, India, Thailand, among many other countries in the region have developed monitoring systems for corals.

Australia's eReefs portal combines an array of data, including sea surface temperature and chlorophyll concentration, to monitor the water quality and coral reef health of the Great Barrier Reef.[45] The ISRO has established a Coral Bleaching Alert system and conducts studies into specific coral bleaching systems for five major Indian Reef regions to study micro-habitat zonation, reef substrate signatures, and the impact of climate change on coral reef ecosystems.[46]

The Thailand Department of Marine and Coastal Resources monitors near real-time sea surface temperature to provide an early warning on when and where action may be needed to protect fragile coral ecosystems from additional pressures, such as tourism, in order to reduce the impact from warming periods, preventing the permanent loss of coral reefs and supporting faster recovery.[47] The Thailand Department of Fisheries also uses space applications to map coastal areas for several purposes, including monitoring fisheries habitats, establishing zoning for aquaculture and fishery activities, and reviewing areas suitable for the establishment of artificial coral reefs.[48]

With support from the International Coral Reef Initiative and coordination by the South Asia Cooperative Environment Programme , South Asian countries have established the South Asian Regional Node of the Global Coral Reef Monitoring Network which has developed a regional information network with a regional coral reef database, providing socioeconomic monitoring information at the reef locations and other information for influencing reef management planning and policy development.[49]

[44] T.P. Hughes and others, "Global warming and recurrent mass bleaching of corals", Nature, vol. 543 (2017). Available at http://eprints.whiterose.ac.uk/123989/1/Hughes%20et%20al.%20Bleaching%20ms%20Feb13.pdf

[45] eReefs, "eReefs – a world-first delivering vital information about the entire Great Barrier Reef from catchment to ocean". Available at https://ereefs.org.au/ereefs

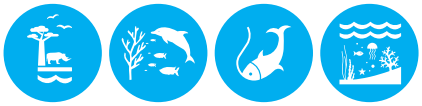
[46] Government of India, Department of Space, Indian Space Research Organization (ISRO), "Environment and climate change", 18 August 2020. Available at https://www.sac.gov.in/Vyom/envandclimate.jsp

[47] Survey input provided by the Thailand Department of Marine and Coastal Resources.

[48] Survey input from the Department of Fisheries, Thailand.

[49] South Asia Cooperative Environment Programme (SACEP) and others, "Improving site-based coral reef management in South Asia: The identification of demonstration and target sites for coral reef management and networking for experience sharing". Available at https://www.icriforum.org/wp-content/uploads/2019/12/South_Asia.pdf

b. Philippines: Seagrass mapping and monitoring



Seagrass meadows play an important role in marine ecosystems for food security, mitigating climate change and supporting biodiversity.[50] Seagrass provides protective habitats for marine organisms, particularly juvenile fish, food for some marine organisms, stabilizes the seabed, and maintains water quality. Seagrass ecosystems are able to create complex three-dimensional habitats to support a biodiverse array of fauna, with some estimates indicating that these habitats support the productivity of almost 20 per cent of the world's fisheries through their role in nursery habitat provision.[51] These environments tend to be so rich and productive in marine life that they are almost always targeted as fishing grounds to support human livelihood and well-being.[52] These ecosystems are threatened globally, with accelerating rates of biodiversity loss and degradation,[53] from over-exploitation due to poor coastal zone management, land reclamation, and declining water quality and pollution. Often, limited recognition of the importance of these ecosystems results in limited monitoring, leaving very little basic data to help governments develop policies for conservation and protection.

The Philippines LIDAR2 programme has been using LiDAR, remote sensing data and GIS to map natural resources such as seagrass, coral, mangrove areas and algae, among other terrestrial resources in order to assess their vulnerability. The programme is a collaborative effort between national universities and colleges, many of which had no previous experience with remote sensing. It provided an excellent opportunity for large scale capacity-building on the effective use of various remote sensing data and tools. The work involved data verification and validation through calibration, ground validation surveys and review of data collection activities to ensure high product quality.[54] Supported by the Philippines Department of Agriculture, the Department of Environment and Natural Resources,

[50] R. K. F. Unsworth and others, "Global challenges for seagrass conservation", *Ambio*, vol. 48 (2019).

[51] Ibid.

[52] Ibid.

[53] Ibid.

[54] Phil-LIDAR, "LIDAR data processing, modelling and validation by HEIS for the detailed resources assessment in Luzon: Region 3 and Pangasinan", Central Luzon State University, Philippines. Available at http://phil-lidar.iccem.com.ph/about-phil-lidar2/

the Department of Energy, and DOST, the LIDAR2 programme produced a detailed inventory of coastal resources.

The Sonar Remote Sensing of Seagrass Meadows (SeaRS) Project of the Philippines used LiDAR, multispectral, hyperspectral and sonar remote sensing data to map seagrass areas in pilot sites, characterising different species in terms of health, measurements of biophysical parameters, biomass, and other parameters needed for carbon stock modelling.

c. Mangrove monitoring and conservation: India, Bangladesh, the University of Hong Kong

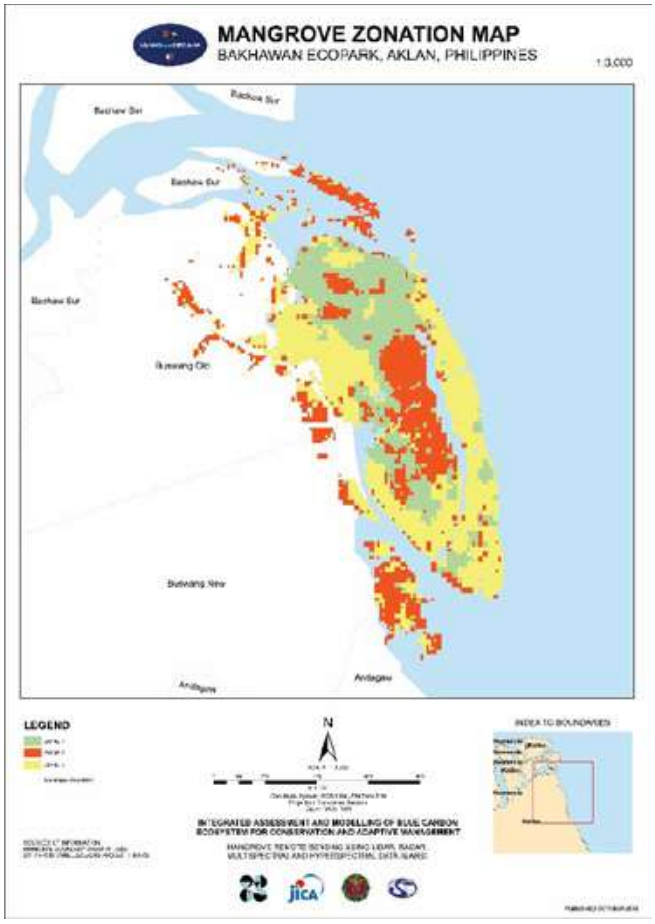
Similar to coral reefs and seagrass, mangroves are extremely biodiverse ecosystems that are critical as nursery grounds for many marine species, including those essential to global fisheries. They purify water, stabilize coastlines, provide protection from storms, and are important sources of food and resources for local communities. Studies indicated that mangroves had been disappearing at a rate of around 1 per cent to 3 per cent per year,[55] between 1980 and 2005 due to human activity, such as urban development, aquaculture and overexploitation of natural resources. Considerable effort, in conservation, has been made more recently, with other studies using remote sensing that indicates that the loss between 2000 and 2012 has been closer to 0.2 to 0.7 per cent.[56]

The Integrated Assessment and Modelling of Blue Carbon Ecosystems for Conservation and Adaptive Management (IAM*Blue*CECAM) programme was established to produce an accurate and detailed inventory of mangrove forests and seagrass habitats using remote sensing and ground-based measurements to provide local officials with information on the mangrove extent and species, enabling more accurate information for conservation and natural resource management.[57]

Detailed maps of mangrove forests in the pilot sites were developed, characterizing the mangrove forests in terms of health, and other parameters needed for carbon stock modelling.[58]

The Chinese University of Hong Kong has been using satellite data and machine learning to monitor mangrove ecosystems, including the area, species, exotic species and biomass. Their project utilizes deep convolutional neural networks with satellite data such as Landsat, Sentinel 2, WorldView, and hyperspectral images from other satellites to determine the dynamic change of mangrove extent and biodiversity for conservation management (Figure 4.6).[59]

Figure 4.5 Mangrove Zonation Map



Source: Republic of the Philippines, Philippine Council for Industry, Energy, and Emerging Technology Research and Development (DOST-PCIEERD), "DOST-PCIEERD project creates online community-based blue carbon assessment tool", 28 May 2019. Available athttp://pcieerd.dost.gov.ph/news/latest-news/351-dost-pcieerd-project-creates-online-community-based-blue-carbon-assessment-tool
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

[55] Food and Agriculture Organization of the United Nations (FAO), "The world's mangroves 1980-2005" FAO Forestry Paper 153 (Rome, 2007).

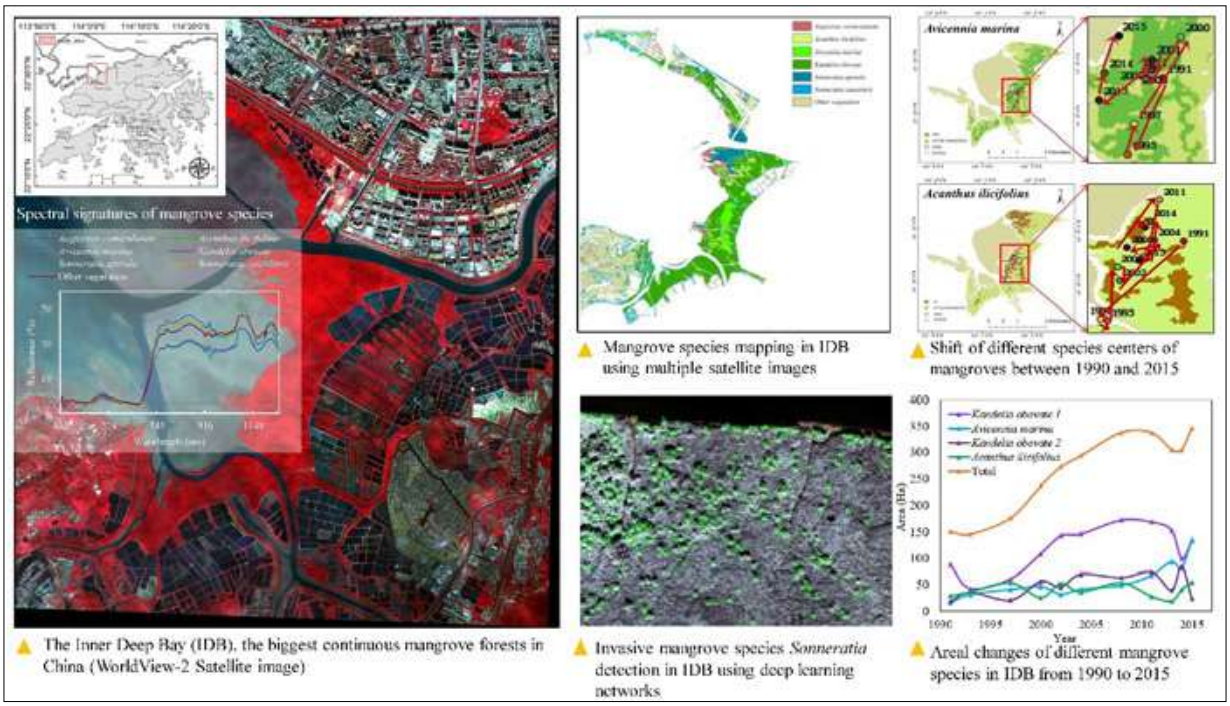
[56] Stuart E. Hamilton and Daniel Casey, "Creation of a high spatio-temporal resolution global database of continuous mangrove forest cover for the 21st century (CGMFC-21)", Global Ecology and Biogeography, vol 25, No. 6 (21 March 2016). Available at https://onlinelibrary.wiley.com/doi/full/10.1111/geb.12449 https://link.springer.com/article/10.1007/s10750-017-3331-z this link is for another article, not the Hamilton one above

[57] Republic of the Philippines, Philippine Council for Industry, Energy, and Emerging Technology Research and Development (DOST-PCIEERD), "DOST-PCIEERD project creates online community-based blue carbon assessment tool", 28 May 2019. Available at http://pcieerd.dost.gov.ph/news/latest-news/351-dost-pcieerd-project-creates-online-community-based-blue-carbon-assessment-tool

[58] Survey response from Philippines RESAP focal point.

[59] Chinese University of Hong Kong survey response.

Figure 4.6 Mangrove mapping using data from WorldView-2 Satellite



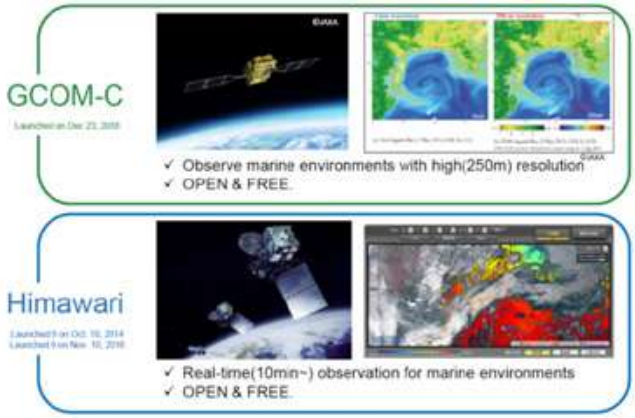
Source: Provided to ESCAP as part of survey response by the Chinese University of Hong Kong.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

The Sundarban Delta (India and Bangladesh) has the world's largest mangrove forest and is named a UNESCO World Heritage Site. The region has been actively using the Spatial Monitoring and Reporting Tool (SMART) to increase the capacity in order to conserve the area. As the custodian of the Sundarban Mangrove Forest, the Bangladesh Forest Department, adopted SMART throughout the entire team responsible for the region in order to conserve the resources, document the biodiversity and prevent illegal activities. SMART has proven to be a very useful tool for the Bangladesh Forest Department to plan their actions given the limited resources and challenges that they face.[60]

d. Japan: Fisheries resource management

Earth observation satellites are useful to help estimate the stocks of fishing resources by providing oceanographic distribution of sea surface temperature, sea surface wind and chlorophyll concentration, in combination with fisheries data stock and a numerical ocean model. The potential fishing grounds (PFG), a promising area for international cooperation, has already been introduced in some Asian countries to help governments with fishery resource management.

Figure 4.7 Japanese satellite assets, GCOM-C and Himawari



Source: JAXA

The existing PFGs are, however, only applicable to pelagic ocean, as their low resolution cannot reflect the influence of coastal topography. On the other hand, coastal fisheries constitute the greater part of the fishermen population in Asia, and thus is more important for national development. Japan is developing a new PFG applicable for coastal seas, in collaboration with Indonesia, using Japanese

[60] German Cooperation, "Enhancing conservation law enforcement and monitoring in the Sundarbans mangrove forest through the Spatial Monitoring and Reporting Tool (SMART)". Available at https://www.snrdasia.org/download/management_of_the_sundarbans_mangrove_forests_for_biodiversity_conservation_and_increased_adaptation_to_climate_change_smp/2017_10_12_SMART-flyer_FINAL.compressed.pdf

satellite assets. Among these, JAXA satellite Global Change Observation Mission-Climate (GCOM-C) is a key asset because its special resolution is much higher (250 metres) than existing satellites equipped with multi-spectrum sensors (Figure 4.9). Coupled with Himawari, a Japanese meteorological satellite, numerical models for coastal seas can also be run.

4. Land use management

Ecosystems services are vital for millions of livelihoods around the world, especially in poor and rural areas. Despite having such high worth and significance for food, shelter and cultural aspects, they are often hard to quantify. Ecosystem services are broken down into four main services; provisioning services, that provide material benefits, such as food, fiber and fuels; regulating services, which include the purification of air and water, the regulation of water flow, which provides a buffer against floods, detoxification, waste breakdown, renewal of soil, pollination of crops and natural pest control; supporting services, which provide plants and animals with living space and cultural services that include non-material benefits for people, such as cultural wellbeing.[61] Ecosystem services are consumed directly or in-directly by all humans and contribute to all livelihoods and to the quality of life, largely representing part of the total economic value of the planet.

Over the past 50 years, population growth and economic development has put more pressure on resource consumption and changed the way in which these resources have been used. Approximately 60 per cent of the benefits provided from global ecosystem services, such as fresh water, clean air and a stable climate, are being degraded and unsustainably used.[62] Humans are now consuming natural resources faster than they can be regenerated and these benefits are not shared equally. Land degradation, soil erosion, deforestation and biodiversity loss are major problems. With an estimated 7.6 million hectares of forests lost every year globally this is impacting soil fertility and productivity, with an annual cost of around $US 2 trillion to $US 5 trillion annually. Remote sensing and space applications have emerged as important tools in land use and ecosystem management. Many countries employ these technologies to monitor changes over time, protect critical ecosystems, such as forests and wetlands, and guide policy decisions.

a. India: Land use mapping through Bhuvan web portal

The ISRO has developed the geoportals Bhuvan[63] and MOSDAC (a data repository for the missions of ISRO) for use to disseminate satellite data, geophysical and biophysical data products as well as thematic information derived using Earth observation (EO) data. The Bhuvan Geoportal provides selected satellite data sets, geophysical products, and thematic layers for consumption at the user's end, either as web services or as free downloads. This geo-portal hosts a variety of data products and applications which are relevant for public use. Several mobile applications have been developed for thematic and geo-governance applications, for collecting field data and are tightly integrated with the Bhuvan portal for visualization and download by authorized users. The portal has been operationally used by at least 30 Central Ministries/ Departments for collaborative mapping, planning, monitoring, evaluation and decision-making in various sectors.

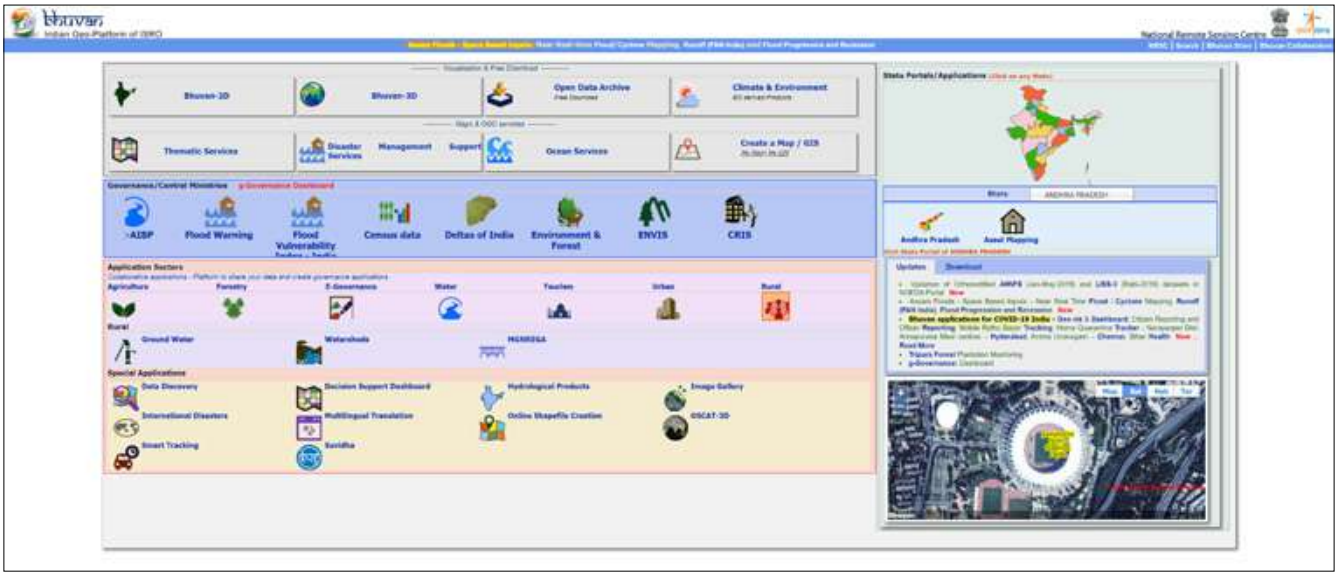
Land use and cover mapping is an important and basic input required for a variety of spatial estimations and modelling in India. Mapping has been conducted annually, since 2014, at a resolution of 56 metres using the multi-temporal AWiFS data of Resourcesat-1/2, primarily aimed at monitoring agricultural areas during the cropping season from June to October, and November to April. Available through India's Bhuvan web portal, this analysis has identified the food secure regions of India and potential areas for improvement. Beyond agricultural purposes however, the land cover analysis is being used for reporting land degradation, water resources, flood forecasting and damage, tiger conservation, renewable energy studies, weather forecasting and soil erosion modelling. It has also been valuable for studies on the expansion of agricultural areas, irrigation, and extrapolation of hydro-meteorological data.

[61] Food and Agriculture Organization of the United Nations (FAO), "Ecosystem Services and Biodiversity (ESB)". Available at http://www.fao.org/ecosystem-services-biodiversity/en/

[62] (MEA, 2005). Millennium Ecosystem Assessment https://www.millenniumassessment.org/en/index.html

[63] Bhuvan, Indian Geo-Platform of ISRO. Available at https://bhuvan.nrsc.gov.in/bhuvan_links.php

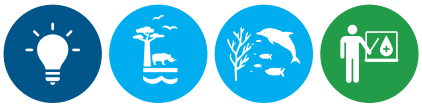
Figure 4.8 Overview of the Bhuvan geo-portal of India



Source: ISRO

Similarly, MOSDAC, a web portal of Department of Space, ISRO, facilitates access to data, information and geo-physical parameters related to weather and ocean state forecasts. This includes data on cyclone tracks, intensity and landfall forecast, high intensity rainfall, cloud bursts and heat waves. The recent addition is ISRO-Cast, where the multicasting/broadcasting techniques are used for dissemination of products to a large number of users.

b. Ecosystem services within the Pacific Islands



The Pacific Islands is also a region that is highly dependent on land and ecosystem services. The Secretariat of the Pacific Regional Environment Programme (SPREP) and the Department of Environmental Protection and Conservation of the Vanuatu Ministry of Climate Change Adaptation, Meteorology, Geo-Hazards, Environment, Energy and Disaster Management have run trainings and capacity-building programmes on GIS to produce basic maps of protected and conserved areas.[64] The training provided skills to officers in order to enable them to make full use of the Pacific Islands Protected Area Portal , a geospatial data portal set up increase efficacy with respect to gaining momentum with communications and conservation work.[65] Officers with expanded geospatial skills will then be able to assist in upcoming initiatives for mapping and ground truthing areas in relation to conservation work.

Conclusion

These examples highlight the wide range of areas in which countries around the region are leveraging space applications for sustainable natural resource management. Natural resources and ecosystem services play a crucial role in the lives of all people, which is why the sustainability of these resources and services is vital. The vast cross-cutting fields that are shown in the examples from the Asia-Pacific region demonstrate the interconnectedness nature that NRM plays in the livelihoods of many. This highlights the importance that space-derived information, its analysis and visualization, offer for the decision-making processes for natural resource management.

This wide range of examples, spanning a variety of practices, demonstrates that the first phase of the implementation of the Plan of Action is on track to address many sub-themes.

[64] Angelicas, "Enhancing Vanuatu's protected areas with GIS and site mapping skills – Island and ocean ecosystems", Secretariat of the Pacific Regional Environment Programme (SPREP), 6 March 2020. Available at https://www.sprep.org/news/enhancing-vanuatus-protected-areas-with-gis-and-site-mapping-skills

[65] SPREP-PROE Pacific Islands Protected Area Portal, "About the Pacific Islands Protected Area Portal (PIPAP). Available at https://pipap.sprep.org/content/about-pacific-islands-protected-area-portal-pipap

Chapter 5.

Space for socioeconomic development - Highlights for connectivity

Seamless connectivity across both the trade and transport, and digital internet and ICT sectors is key for enhancing regional economic cooperation and integration in the Asia-Pacific region.[1] Many countries within the region are becoming more connected, both digitally and physically, with increased access to technology and resources. Internet access within the region is high, but there is still a widening digital divide, especially in poorer and vulnerable regions.

Among the six thematic areas of the Asia-Pacific Plan of Action on Space Applications for Sustainable Development (2018–2030) (Plan of Action), connectivity is expected to enable goods, services, people and information to move efficiently across borders without facing unnecessary barriers. By facilitating telecommunication technology inclusiveness, intelligent transport systems, and smart city planning, connectivity in the region will play

[1] Enhancing Regional Economic Cooperation and Integration in Asia and the Pacific (United Nations publication, Sales No. E.18.II.F.5). Available at https://www.unescap.org/publications/enhancing-regional-economic-cooperation-and-integration-asia-and-pacific

a fundamental role in the attainment of many SDGs, some of which are shown below. Looking forward, the development and application of space science and technologies will be essential, not only to optimize the expansion of products, such as the information highway, traffic management, and smart cities, but also to provide further insights into the socioeconomic impacts of such connectivity. Additionally, the Asia-Pacific region is expected to witness a range of new frontier technologies rendering faster and more versatile connectivity.

Countries within the Asia-Pacific region are already making progress toward building connectivity and access to technology and communication services, but there is still more progress to be made. This section highlights such country practices and experiences from around the region, with a focus on telecommunication services, transport and traffic management, urban and territorial planning and smart cities.

1. Access to telecommunication services

The progress towards the SDGs places more demands on digital communication infrastructures, such as internet and mobile coverage. Inclusive connectivity, made possible by telecommunication technologies, spreads extensive benefits to marginalized people. The recent COVID-19 pandemic and the accompanying surge in bandwidth demand accentuated this need.[2] Crucial activities, such as remote learning and working, demand reliable and affordable means of telecommunication. However, despite the rapid growth of ICT and Internet services within the Asia-Pacific region, there is a widening digital divide between and within the countries in the region.[3] Fixed broadband subscriptions per 100 inhabitants are highest in the Pacific (33 per cent). This is followed by East and North-East Asia (32 per cent), North and Central Asia (20 per cent), South-East Asia (7 per cent), South and South-West Asia (3 per cent) and the Pacific Developing (excluding Australia and New Zealand) (1per cent).[4] With the emergence of Internet bandwidth intensive technologies, countries with low bandwidth capacity may find it increasingly difficult to capitalize on the opportunities presented by such innovations.To address this situation, ESCAP Member States endorsed a 2019 resolution on "advancing the implementation of the Asia-Pacific Information Superhighway (AP-IS) initiative through regional cooperation".[5] The resolution's Master Plan 2019-2020 prioritizes establishment of a sufficient number of Internet exchange points, at the national and sub-regional levels to minimize transit costs and improve Internet speed.[6] Today, with the assistance of technologies, such as satellite communication and geospatial information, it has become more efficient to support low-cost information and communications technology, providing cost-effective Internet access, especially for poorer communities.

Myanmar: Surge in satellite-enabled telecommunication services

Committed to the eventual achievement of a digitally inclusive society, the Government of Myanmar values the need to bring affordable telecommunications throughout the country to support social and economic development. In recent years, Myanmar

[2] United Nations, Economic and Social Commission for Asia and the Pacific (ESCAP). Socio-Economic Response to COVID-19: ESCAP Framework. Available at https://www.unescap.org/sites/default/files/ESCAP%20COVID-19%20Framework%20Paper.pdf

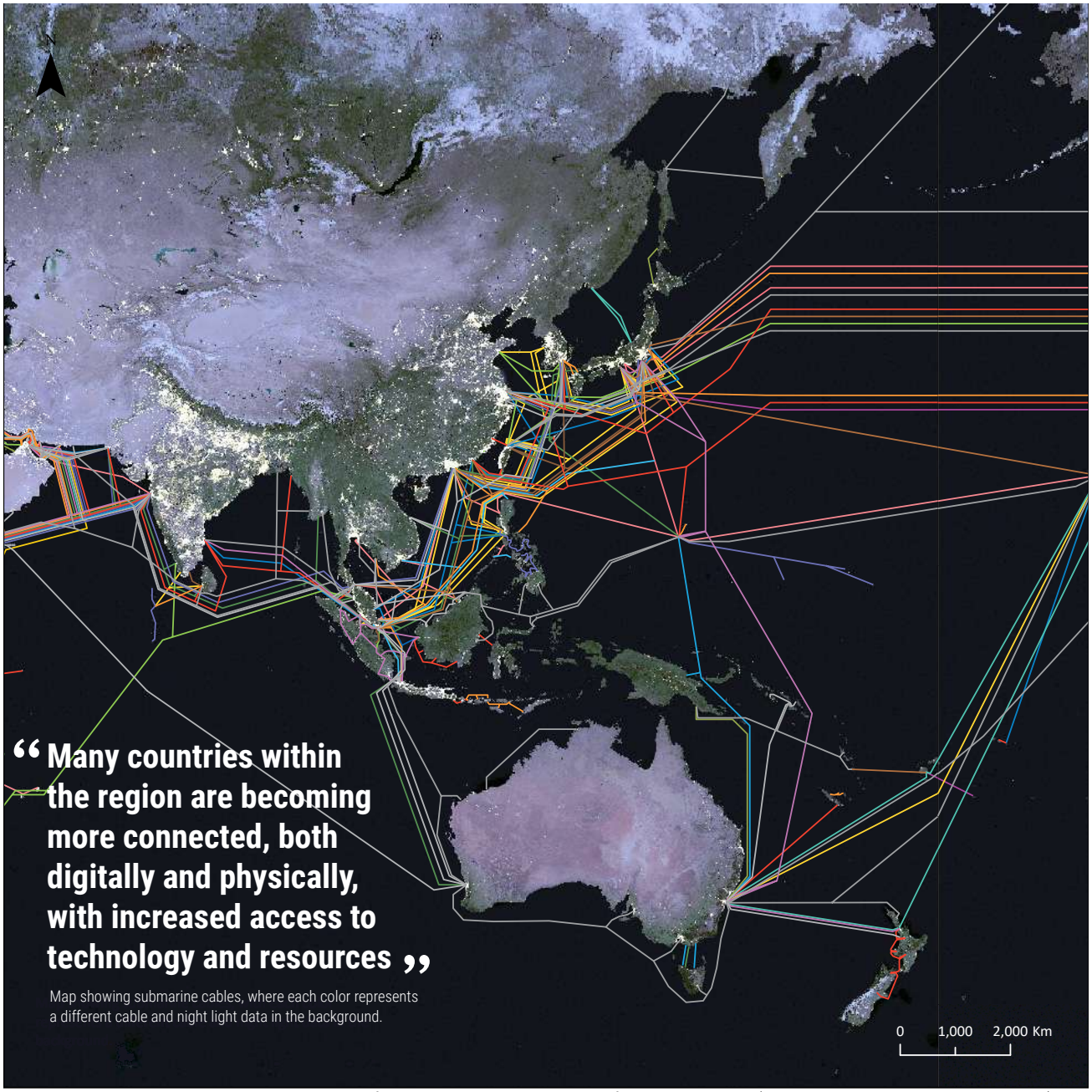
[3] United Nations Economic and Social Council, Promoting regional cooperation for inclusive broadband connectivity through the Asia-Pacific Information Superhighway initiative, Economic and Social Commission for Asia and the Pacific Committee on Information and Communications Technology, Science, Technology and Innovation, Third session. Note by the Secretariat. 19-20 August 2020, Bangkok. (ESCAP/CICTSTI/2020/2).

[4] Fixed broadband subscriptions per 100 inhabitants are highest in the Pacific (33 per cent). This is followed by East and North-East Asia (32 per cent), North and Central Asia (20 per cent), South-East Asia (7 per cent), South and South-West Asia (3 per cent) and the Pacific Developing (excluding Australia and New Zealand) (1per cent). FOOTNOTE With the emergence of Internet bandwidth intensive technologies, countries with low bandwidth capacity may find it increasingly difficult to capitalize on the opportunities presented by such innovations.

[5] ESCAP/RES/75/7; See Resolution adopted by the Economic and Social Commission for Asia and the Pacific.

[6] ESCAP/75/INF/5; See Master Plan for the Asia-Pacific Information Superhighway, 2019-2020. Available at https://www.unescap.org/commission/75/document/E75_INF5E.pdf

Submarine cables and night light data in the Asia-Pacific region



“Many countries within the region are becoming more connected, both digitally and physically, with increased access to technology and resources”

Map showing submarine cables, where each color represents a different cable and night light data in the background.

Map developed by ESCAP. Data Source: Night light data from NASA and Submarine Cables from TeleGeography (https://www.submarinecablemap.com/#/)
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

has made significant progress by granting millions of people access to mobile phone and Internet services, thanks to satellite and Very Small Aperture Terminal development. With Myanmar's diverse geography, land-rights terrain and climate conditions, the installation of cellular towers has been challenging.[7] Thus, the Government of Myanmar turned to a satellite communication system, recognizing its versatility and its ability to provide services to islands and remote villages in a shorter time frame compared to fixed-line penetration.[8]

In May 2016, Myanmar leased a channel on an Intelsat commercial communications satellite, naming it MyanmarSat-1.[9] For the second phase, Myanmar

[7] Nandini Sharma, “Southeast Asian space programmes – capabilities, challenges and collaborations”, SpaceWatch.global. Available at https://spacewatch.global/2019/03/spacewatchgl-feature-southeast-asian-space-programmes-capabilities-challenges-and-collaborations/

[8] U Win Aung, IT and Cyber Security, Ministry of Transport and Communications, Keynote address for Myanmar Satellite Forum 2018, 8 November 2018. Available at http://www.talksatellite.com/MSF2018-Promo%205.htm

[9] SpaceWatch.global, “Myanmar government and Japan's Hokkaido University discuss building earth observation satellite”. Available at https://spacewatch.global/2019/05/myanmar-government-and-japans-hokkaido-university-discuss-building-earth-observation-satellite/

established a joint radar satellite communications laboratory with China, in 2018, allowing Myanmar engineers to access know-how and technologies for building their own communications satellite.[10] As a result, MyanmarSat-2 was launched into space in August 2019. The launch of MyanmarSat-2 aims to provide 95 per cent of Myanmar's population with better communication, healthcare services, and education under the country's e-government program. Equipped with latest technologies, MyanmarSat-2 can offer eight to ten times faster services than its precursor MyanmarSat-1, in not only mobile Internet, but also other communication networks across the country.[11] Meanwhile, MyanmarSat-2 is also a step towards reducing dependency on foreign-owned systems, providing security in communications to its citizens.[12]

The Government of Myanmar rapidly defined a policy framework for Very Small Aperture Terminal licensing to open up the national market for satellite operators,[13] who have been able to educate the market and design remote solutions for rural Myanmar.[14]

[10] Ibid.

[11] Xinhua, Myanmar Satellite-2 to provide better connectivity across country: official, 8 August 2019. Available at http://www.xinhuanet.com/english/2019-08/08/c_138293830.htm

[12] Nandini Sharma, "Southeast Asian space programmes – capabilities, challenges and collaborations", SpaceWatch.global. Available at https://spacewatch.global/2019/03/spacewatchgl-feature-southeast-asian-space-programmes-capabilities-challenges-and-collaborations/

[13] See SOUTHEASTASIANET (SEANET) TECHNOLOGIES Myanmar Co., Ltd. Available at http://www.seanetmsc.com/seanetmyanmar/index.php?idx=0 and See Hughes Network Systems. Available at https://www.hughes.com

[14] Helen Jameson, "Myanmar: The new hotbed for satellite", Via Satellite. Available at http://interactive.satellitetoday.com/via/asia-edition-2017/myanmar-the-new-hotbed-for-satellite/

2. Transport management and traffic navigation

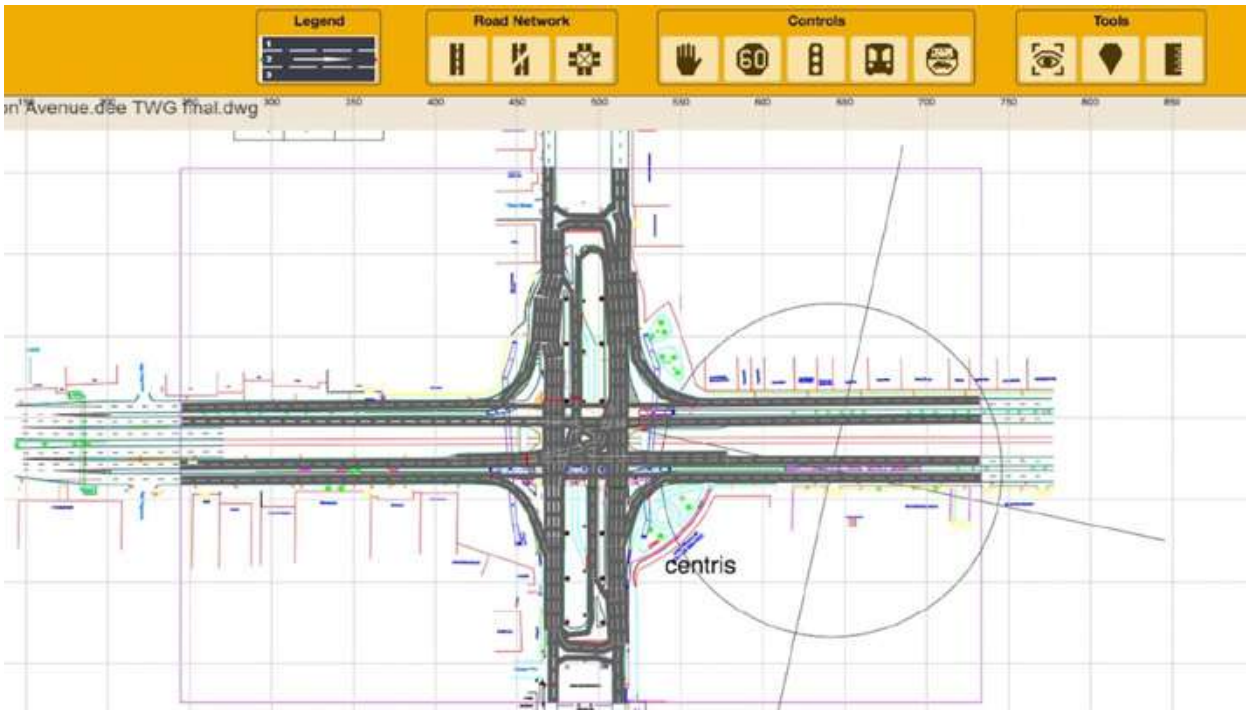
Transport is a driving force behind a prosperous and inclusive economy, as it is an essential part of a well-connected and ever-shrinking world, powering lives and livelihoods. The Asia-Pacific region's demand for transport of people and cargo is consistently increasing due to high population and economic growth, and urbanization rates. Thus, developing a sustainable transport system to exercise proper control over the demand pressure promises key benefits, such as improved road safety, efficient urban access, and better air quality. The targets within the SDGs that will benefit from sustainable transport management include: road safety (target 3.6), energy efficiency (target 7.3), sustainable infrastructure (target 9.1), urban access (target 11.2), and fossil fuel subsidies (target 12.c).[15]

a. Philippines: Use of frontier technologies to address road traffic incidents: LocalSim

LocalSim Developed by the Department of Science and Technology -Philippine Council for Industry, Energy, and Emerging Technology Research and Development (DOST-PCIEERD), LocalSim is a traffic simulation software designed to serve as a decision

[15] SLOCAT Partnership, Transport Targets of Sustainable Development Goals. Available at https://slocat.net/transport-targets-sustainable-development-goals/

Figure 5.1 Local Traffic Simulation (LocalSim) User Interface



Source: Department of Science and Technology -Philippine Council for Industry, Energy, and Emerging Technology Research and Development (DOST-PCIEERD).

support tool for traffic management.[16] The main users are road and traffic engineers of Local Government Units (LGUs). Before the implementation of LocalSim, LGU had to rely on costly, trial-and-error type of social experiments to evaluate traffic improvement schemes. With the modelling ability of LocalSim, LGUs can reduce both financial costs and public criticism for experimenting, while producing objective, smart, and evidence-based traffic management schemes.[17]

LocalSim operates by replicating the road network (Figure 5.1). The system uses a guide map to trace odometers, the number of vehicles, the type of vehicles, and the number of lanes.[18] Users can change traffic schemes with different variables and compare these schemes for all types of movements or for the average delay per vehicle per cycle. The variables, that are supported by LocalSim, include but are not limited to truck bans, exclusive truck lanes, exclusive motorcycle lanes, lane or road closures, one-way traffic, speed restrictions, U-turns, number-coding, bus stop segregation, bus loading areas, traffic signal controls, turning restrictions, grade separations, and stop/yield controls.[19] LocalSim is also designed to explicitly replicate the local driving behaviours, such as the distance between cars, propensity to change lanes, and propensity to swerve.[20]

b. Hong Kong, China and Indonesia: Crash hot zone analysis

Researchers at the University of Hong Kong, China developed methodological advances in the spatial analysis of road crashes and road safety. These include the fast-computing "Hotzone Generation Add-in",[21] and "Hot Clusters Add-in",[22] in GIS to detect road segments of a higher density of traffic crashes. The add-ins have been applied to identify traffic crash hot zones in Hong Kong, China and Indonesia to promote road safety.[23]

[16] Jackie Jane O. Aberilla, "Capturing 'Pinoy-ness' in traffic planning and management, One Expert, 23 May 2017. Available at https://news.oneexpert.gov.ph/stii-bridge/capturing-pinoy-ness-traffic-planning-management/

[17] Philippine Council for Industry, Energy, and Emerging Technology Research and Development (PCIEERD), Department of Science and Technology, "Innovations" Annual Report 2016. Available at http://pcieerd.dost.gov.ph/images/downloads/publications/PCIEERD_AR_2016.pdf

[18] DOST PCIEERD, Innovation Council, "Local Traffic Simulator (LocalSim)", video, 5 September 2019. Available at https://youtu.be/ZnBcVji7Yz0

[19] Ibid.

[20] Ma. Cristina Arayata, "DOST, DILG set convergence meeting for research adaptation", Philippine News Agency, 2 July 2019. Available at https://www.pna.gov.ph/articles/1073876

[21] ArcGIS, Hotzone Generation Addin. Available at https://arcg.is/1OmeTK

[22] ArcGIS, HotClusters Addin. Available at http://arcg.is/0rHGGH

[23] ArcGIS, "Where are the most dangerous road locations in Hong Kong, China: An investigation of traffic crash hot spots and hot zones", 1 April 2020. Available at https://arcg.is/jCWTX

The add-ins can help target those dangerous road locations that were not previously identified by the traditional hot spot methodology. The traditional hot spot methodology usually detected a single point of high crash density (i.e., intersections), but failed to detect some continuous road segments (i.e., at least two basic spatial units) of high crash density. These add-ins help bridge this gap. Location-specific countermeasures can be devised, based on the hot zone analysis, which help to formulate target-specific measures. The add-ins can be universally used by road safety administrations, consultancies, as well as researchers to identify hot zones of road crashes by giving precise spatial locations of crash data. With the adoption of the hot-zone elimination programme, it is expected that a more focused programme on reducing road crashes on highways and rural roads can be developed. Targets of crash reduction can be set and road safety can be improved.

c. Sri Lanka: Vessel traffic management system

With new prospects in satellite and space related technologies, Sri Lanka is taking advantage of the flourishing applications, within the navigation satellite technology, that play a core role in the majority of modern location-based services (LBS).[24]

A vessel traffic management system (VTMS) is a nautical vessel movement observing system. It utilizes information collected by advanced sensors, such as, radars, automatic identification sensors, CCTV, Meteor-Hydro and other electronic object detection systems. The primary purpose of VTMS is to improve the safety and efficiency of navigation, improve features of port services, protect life at sea, and safeguard the marine environment.[25, 26, 27]

Strategically located in South-East Asia, Sri Lanka is close to many emerging markets and is already an important logistics hub for the region.[28] Ports in Sri Lanka have faced significant growth, driven by the increasing demand of services, in the international shipping industry and in major infrastructure development programmes, setting the Colombo Port as a new maritime trans-shipment hub in the Indian Ocean.[29] To alleviate the stress, Sri Lanka Ports Authority successively implemented VTMS for ports in Sri Lanka. For example, the Colombo Port received its VTMS in May 2014 from SIGNALIS,[30] expanding its capacity to six million, twenty-foot equivalent container units (TEUs) by 2016 and to seven million TEUs by 2018.[31]

d. India: Use of geospatial technologies in transport management and traffic navigation

India has been making significant progress in responding to the demands of today's cities by incorporating robust space technologies and GIS into the urban planning, transport management and traffic navigation techniques.

Road Asset Management system

The development of Road Asset Management system for National Highways (NHs) is a flagship project by the National Highways Authority of India in association with the Indian Space Research Organization (ISRO) and the World Bank. Bringing both public and private funded roads under one umbrella, the main objective of this project is to assist in accurate and scientific maintenance planning, enhance road safety measures and plan the development of the NH network in India.[32]

[24] I.P. Senanayake, "Anticipated prospects and civilian applications of Indian satellite navigation services in Sri Lanka", *The Egyptian Journal of Remote Sensing and Space Science*, vol. 16, No. 1 (20 May 2013). Available at https://www.sciencedirect.com/science/article/pii/S1110982313000045

[25] Joseph Akwasi Kuma, "Vessel traffic service as a maritime security tool: vessel traffic management information systems (VTMIS) in Ghana", dissertation, World Maritime University, 2015. Available at https://commons.wmu.se/cgi/viewcontent.cgi?article=1492&context=all_dissertations

[26] U. S. Department of Homeland Security, Navigation Center, "Vessel Traffic Services". Available at https://www.navcen.uscg.gov/?pageName=vtsMain

[27] UKEssays, "Vessel traffic management system (VTMS)", November 2018. Available at https://www.ukessays.com/essays/statistics/vessel-traffic-management-system.php

[28] Government of Sri Lanka, "National Export Strategy of Sri Lanka: Logistics Strategy, 2018-2022". https://www.srilankabusiness.com/pdf/nes/sri-lanka-logistics-4-3-web.pdf

[29] Naval Technology, "SIGNALIS delivers the first Vessel Traffic Management System (VTMS) to Sri Lanka", SIGNALIS Press Releases, 28 April 2014. Available at https://www.naval-technology.com/contractors/decoy_defensive/signalis/pressreleases/presssignalis-delivers-system-sri-lanka/

[30] Ibid.

[31] Sri Lanka Ports Authority, "History & Milestones". Available at https://www.slpa.lk/port-colombo/slpa

[32] Federation of Indian Chambers of Commerce & Industry (FICCI), "Geospatial Technologies in India: Select Success Stories", 2017. Available at http://ficci.in/spdocument/20873/Geospatial%20Technologies%20in%20India%20-%20Success%20Stories.pdf

Taking international best practices as global benchmarks, the project makes an optimal use of geospatial technologies for the planning and management of the National Highways, for monitoring road segments under construction, for analysing the patterns of congestion and traffic jams, for better junction arrangement planning, for examining the land use situation for development of NHs and for strengthening road safety measures by identifying black spots. Under this project, a web-based software system has been developed to collect location-based, spatial data for more than 200 attributes of a road. With this comprehensive system of data collection, major stakeholders, like the Transport Ministry, Finance Ministry, National Highways Authority of India, state public works department, police departments, funding agencies, developers and citizens are able to conduct map audits and extract relevant information which is readily available within the system. The software is also equipped to interface with the indigenous *Bhuvan* satellite images.[33]

Smart Buses: GIS-based School Bus tracking

The school transportation system in India is a non-organized sector with only a few measures taken by the schools and transporters to ensure the safety and security of the children. The rate of increase in transport related incidents is worrisome and has created an urgent need for school administrations to invest optimally in their transport management system. In this direction, many state governments have mandated the installation of GPS devices in the school buses transforming them into smart buses. Combining geospatial and mobile technologies addresses the problems faced by parents as capacities have been developed to monitor and track, in real time, the school buses from anywhere, anytime. The mobile applications give regular information alerts about the arrival and departure of school buses and their exact geo-location. In addition to providing convenience to parents, the GIS-based bus tracking system also ensures a safety cover in terms of drivers being conscious of being monitored. School Transport can use a geospatial dashboard to monitor the status of buses and take corrective measures in case of any violations of traffic rules. Business Intelligence and Analytics may add further dimension in providing reports and models which can help school transport authorities to optimize maintenance and fuel cost, reduce speed and route violations and ensure an overall monitoring of fleet movement based on historical location data.[34]

3. Urban and territorial planning

For the first time in history, over 50 per cent of the population in the Asia-Pacific region is living in cities.[35]

[33] Bhuvan, Indian Geo-Platform of ISRO. National Remote Sensing Centre. Available at https://bhuvan.nrsc.gov.in/bhuvan_links.php and in text link to section on Bhuvan

[34] Ibid.

[35] *The future of Asian & Pacific cities: Transformative pathways towards sustainable urban development*, (United Nations publication, Sales No. E.20.II.F.1). Available at https://www.unescap.org/sites/default/files/publications/Future%20of%20AP%20Cities%20Report%202019_0.pdf

This rapid urbanization process is accompanied by challenges, but also brings new opportunities for urban planning. Urban and territorial planning is a decision-making process aimed at realizing economic, social, cultural and environmental goals through the development of spatial visions, strategies and plans. Combined with the application of a set of policy principles, tools, institutional and participatory mechanisms and regulatory procedures.[36] Urban and territorial planning is an essential tool for creating better urban spaces. Through thoughtful planning, cities can provide adequate housing, efficient transport and employment with regard to a growing or shrinking population. The Plan of Action recognizes the augmented availability of geospatial information, as a key part of rapid digital innovation, provides countries within the Asia-Pacific region, particularly those with special needs, with an expanded choice of tools to implement the 2030 Agenda.

Technological innovations have made planning data and tools more accessible, affordable and efficient. These new technologies offer unprecedented opportunities to support more informed and integrated planning decisions. Traditional paper-based land surveys and records can be resource-intensive and difficult to maintain. Today, cities are successfully adopting space applications and geospatial data to store, manage and visualize information, thus supporting analytics towards more informed and integrated planning decisions. Several initiatives even provide databases that compliment crowdsourced data from communities. The resulting products are more compact, socially inclusive, better integrated and connected cities that foster sustainable urban development and are resilient to climate change.[37] The following country practices illustrate this progress.

a. Singapore: Integrated urban planning

In partnership with other national planning agencies, Singapore's Urban Redevelopment Authority introduced the GIS-Enabled Mapping Modelling and Analysis (GEMMA), which is a decision support tool for planners to conduct integrated planning analytics and simulation.[38] GEMMA combines data from various platforms, offering a tool to overlay, merge and model different layers of data for advanced analysis and visualization of information relevant to urban planning. It offers stakeholders, across multiple agencies, the access to a variety of map-based data required for planning, such as existing and future land use commitments, transport network performance, population demography, as well as location and capacities of utilities and amenities. It further offers planners the option to compose planning scenarios, analyse different site options, and assess its impact from a local to a national level. Through this platform, planners from different agencies can collaborate and jointly assess planning options and inter-dependencies, further strengthening the integrated planning process.[39] For example, GEMMA allows planners to identify optimal placement of new facilities and amenities by analysis and visualization of connectivity, distances to residential areas, public transport nodes, etc. This data in turn can also inform the development and improvement of the public transportation network.

b. Brisbane, Australia: 3D sustainable growth model

The Brisbane City Council, in Australia, created a digital map to document and support city development activities. Virtual Brisbane is an innovative, computer-generated, 3D model of urban development activity in Brisbane that enables the detailed visualization and analysis of development plans in relation to the existing urban environment (Figure 5.2).[40]

The model combines accurate 2D and 3D data from multiple agencies and is a key strategic planning, development assessment and community engagement tool, that assists in the local decision-making processes. Built-in assessment tools help quantify cumulative impacts of proposed developments on surrounding areas. The Virtual Brisbane digital map is openly available online, offering

[36] UN-Habitat, International Guidelines on Urban and Territorial Planning, document HS/059/15E. Available at https://unhabitat.org/international-guidelines-on-urban-and-territorial-planning

[37] Ibid

[38] Urban Redevelopment Authority, "Harnessing the power of digital technologies", 26 November 2017. Available at https://www.ura.gov.sg/Corporate/Resources/Ideas-and-Trends/Harnessing-the-Power-of-Digital-Technologies

[39] Ibid.

[40] Amit Roy Choudhury, "Using maps to build smarter cities", GovInsider. 16 November 2018. Available at https://govinsider.asia/smart-gov/using-maps-to-build-smarter-cities/

Figure 5.2 Overview of the Virtual Brisbane 3D Model

Source: Brisbane City Council

residents insight into the city's planning process and future development scenarios.[41]

4. Smart City

A Smart City is a city that leverages various Internet of Things (IoT) sensors, Big Data and other innovative technologies to manage assets, resources, and services efficiently. For example, smart cities leverage these technologies to monitor and manage systems, such as: traffic systems, energy, waste, schools, hospitals and other community services. The implementation of smart city visions, however, is not without its challenges and cities in the region need to build up robust digital infrastructure, especially broadband connectivity, to support these smart solutions.[42]

The emergence of the "Smart City" concept provides a pathway for city administrators to address these challenges and to achieve sustainable development. Countries within the region, namely China, India, Indonesia and the Republic of Korea have demonstrated great enthusiasm for promoting the establishment of smart cities in their countries. The market research firm has launched the Smart City Asia Pacific Awards to recognize the outstanding Smart City projects.[43] Smart City Asia Pacific Awards establishes a forum for sharing best practices of municipalities in the Asia-Pacific region. In 2018, ASEAN established the ASEAN Smart Cities Network, which is a collaborative platform where cities from the ten ASEAN Member States work towards the common goal of smart and sustainable urban development.[44] The primary goal of the ASEAN Smart Cities Network is using technology as an enabler to improve the lives of ASEAN citizens. National governments have also rolled out ICT and smart city plans, such as the India Smart Cities Mission,[45] and Indonesia's plan to build 100 smart cities, which demystifies the role of ICT in smart city development and encourages innovative solutions and entrepreneurship. Other examples include a 3D Singapore Smart City Map developed by Singapore Land Authority (SLA),[46] and the Hangzhou,

41 Brisbane City Council, "Virtual Brisbane". Available at https://www.brisbane.qld.gov.au/planning-and-building/planning-guidelines-and-tools/other-plans-and-projects/virtual-brisbane

42 *The future of Asian & Pacific cities: Transformative pathways towards sustainable urban development*, (United Nations publication, Sales No. E.20.II.F.1). Available at https://www.unescap.org/sites/default/files/publications/Future%20of%20AP%20Cities%20Report%202019_0.pdf

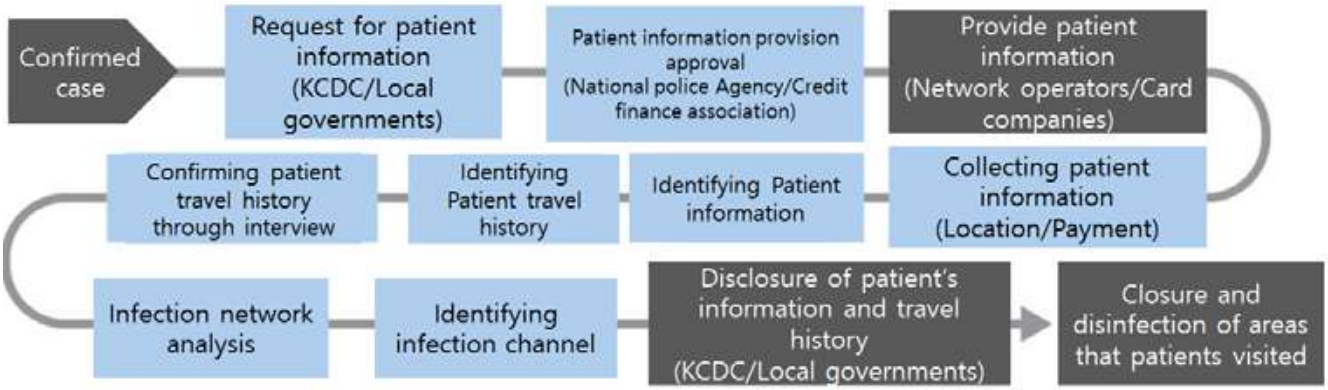
43 IDC Smart City, "Overview". Available at https://www.idc.com/ap/smartcities/

44 Association of Southeast Asian Nations, "ASEAN Smart Cities Network". Available at https://asean.org/asean/asean-smart-cities-network/

45 Government of India, Ministry of Housing and Urban Affairs, "Smart Cities". Available at http://mohua.gov.in/cms/smart-cities.php

46 Johnson Ang, "Singapore smart nation embraces 3D land management", LIDAR Magazine, 04 January 2019. Available at https://lidarmag.com/2019/04/01/singapore-smart-nation-embraces-3d-land-management/

Figure 5.3 COVID-19 public health surveillance support system process



Source: The Kyunghyang Shinmun. Available at http://news.khan.co.kr/kh_news/khan_art_view.html?art_id=202003252141005

China City Brain that gathers real-time traffic data from intersection cameras and GPS data on vehicles and buses. It then leverages AI technologies to analyse data for alleviating traffic congestion, minimizing road accidents and even cutting down on crime.[47]

a. The Republic of Korea: Ubiquitous-City (U-City) technology leveraged during the COVID-19 pandemic

Ubiquitous-City (U-City) is the Republic of Korea's project for building smart cities. It was launched in the early 2000s, focusing on new cities such as Hwaseong Dongtan and Incheon. To respond to the COVID-19 pandemic, the Ministry of Land, Infrastructure and Transport, Korea Centers for Disease Control and Prevention, and the Ministry of Science, ICT and Future Planning are operating a COVID-19 public health surveillance support system. This system is also supported by the National Police Agency, the Credit Finance Association, Network Operators and 22 credit card companies.[48]

The COVID-19 public health surveillance support system automates the public health surveillance process by utilizing smart city technologies (Figure 5.3). The system allows real-time analysis of Big Data to automatically identify the travel history of confirmed COVID-19 cases, including the location of their stay and time frame. The system also enables various statistical analysis on large-scale outbreak areas (hotspots) to identify sources of infection. Thanks to smart city technologies, rapid and accurate acquisition of information has been made possible. In the early stage of the COVID-19 outbreak, analysing travel history of confirmed patients and the public health surveillance process took around 24 hours. After applying the smart city technology, the same work was completed within 10 minutes.

[47] David Ho, "Street smart", *China Daily*, 23 December 2017. Available at http://usa.chinadaily.com.cn/a/201712/23/WS5a3d67d3a31008cf16da2fb4.html

[48] Republic of Korea, Ministry of Land, Infrastructure and Transport (MOLIT). Available at http://www.molit.go.kr/USR/NEWS/m_71/dtl.jsp?lcmspage=1&id=95083710

Conclusion

The examples within this chapter highlight how countries in the region are utilizing space applications within connectivity based fields. Seamless connectivity plays a crucial role in the region by enabling goods, services, people and information to move efficiently across borders without facing unnecessary barriers. Digital connectivity also plays a large role in enabling new innovative digital solutions for sustainable development. It has been demonstrated, especially during the COVID-19 pandemic, that digital connectivity and solutions are more important than ever. The cross-cutting fields that are shown in the examples from countries around the region illustrate the importance of connectivity, especially digital connectivity. This also highlights the importance that space applications and geospatial tools offer in the decision-making processes for connectivity driven fields.

The Asia-Pacific region has the opportunity to bridge the digital divide and this wide range of examples, spanning a variety of practices, demonstrates that several countries are on track to address many actions under the first phase of implementation of the Plan of Action.

Chapter 6.

Space for socioeconomic development - Highlights for social development

Driven by significant economic growth, the Asia-Pacific region has witnessed growth in income, jobs, and access to basic services and opportunities. However, the resulting progress in social development should not undermine our attention towards the widening gaps in social structures and the growing number of individuals living in vulnerable situations. Some 400 million people in the Asia-Pacific region remain trapped in extreme poverty at $US 1.90 per day and 1.2 billion people at $3.2 per day.[1] In a number of countries in the Asia-Pacific region, less than 40 per cent of people have access to modern financial services, and significant gender gaps exist.[2] The population ageing phenomenon is also reducing the labour force in many countries and causing economic strain.[3]

[1] *Sustainable Social Development in Asia and the Pacific: Toward a People-Centred Transformation* (United Nations publication, Sales No. E.17.II.F.15). Available at https://www.unescap.org/sites/default/files/publications/Sustainable%20Social%20Development%20in%20A-P.pdf

[2] Ibid.

[3] *Aging and its Economic Implications*, Social Development Policy Papers 2020/01 (ST/ESCAP/2903). Available at https://www.unescap.org/sites/default/files/Ageing%20and%20its%20economic%20implications.pdf

Sustainable development in the region is only attainable with a strong social foundation, which ensures that no one is left behind. To work toward socioeconomic development and achieving the SDGs it is vital to leverage both past experience and the prowess of new technological advancements.[4, 5] The Asia-Pacific Plan of Action on Space Applications for Sustainable Development (2018-2030) (Plan of Action) highlights the potential of using geospatial information, including Earth observation data, in support of mapping poverty and vulnerable groups, identifying health risk hotspots and monitoring and cleaning up pollution. To review the regional implementation status of the Plan of Action, this section will highlight country practices and experiences in social development, with a focus on social development in urban planning, health management (specifically COVID-19), contamination and pollution and capacity-building.

1. Social development in urban planning

For the past 30 years, the Asia-Pacific region has been leading the charge towards urban transformation.[6] Over 50 per cent of the region's population now lives in urban settings. Meanwhile, cities in the Asia-Pacific region have transformed into major components of the global economy, significantly improving the quality of life of residents with an increase in middle class residents and a decrease in the percentage of slum dwellers.[7] While the goal of eliminating extreme urban poverty is becoming increasingly likely with these positive developments,[8] cities in Asia and the Pacific should continue to review their urban planning and management in the face of increasing consumption and production.[9] Social justice and inclusion are becoming priorities for urban development models.[10] Meanwhile, urban inequality remains a complex synthesis of income, access to land and housing, physical infrastructure and services, health and education facilities, social security networks, and voice and empowerment.[11] The information and relationships required to be analysed for inequalities in modern cities can easily overwhelm traditional information systems and data collection methods.[12] To avoid the information gaps resulting from inefficient data processing, it is imperative to integrate geospatial, statistical, and other information for urban policy.[13] The following examples showcase the urban planning policies and initiatives that are informed by geospatial data and technologies.

a. The Atlas of Urban Expansion

The Atlas of Urban Expansion,[14] was developed as a tool to monitor quantitative and qualitative aspects of global expansion by the New York University Urban Expansion Program at the Marron Institute of Urban Management,[15] and the Stern School of Business in New York University, in partnership with UN-Habitat and the Lincoln Institute of Land Policy. Following a phased approach, this research programme aims at monitoring urban expansion in 200 global cities. Through the collection and analysis of qualitative and quantitative data, this tool helps in understanding the growth of cities, providing policymakers support in long-term preparation for urban expansion.

4 United Nations, Department of Economic and Social Affairs (DESA), "Twenty-five years of the World Summit for Social Development: Addressing emerging societal challenges to the implementation of the 2030 Agenda", Draft Concept Note, Ministerial Forum, 11 February 2020. Available at https://www.un.org/development/desa/dspd/wp-content/uploads/sites/22/2020/02/Draft-ConceptNote-CSocD58-MinisterialForum.pdf

5 United Nations, Economic and Social Commission for Asia and the Pacific (ESCAP), "Asia-Pacific Plan of Action on Space Applications for Sustainable Development (2018-2030)". Available at https://www.unescap.org/sites/default/files/3rdMC-SASD-Plan-of-Action.pdf

6 United Nations, Economic and Social Commission for Asia and the Pacific (ESCAP), UN-Habitat, Habitat III Secretariat, "Transformative urbanization for a resilient Asia-Pacific", Regional Report Asia and the Pacific, 2017. Available at http://habitat3.org/wp-content/uploads/Habitat-III-Regional-Report-Asia-Pacific.pdf

7 Ibid.

8 Ibid.

9 United Nations, Economic and Social Commission for Asia and the Pacific (ESCAP), UN-Habitat, "The State of Asian and Pacific Cities 2015: Urban transformations shifting from quantity to quality", 2015. Available at https://www.unescap.org/sites/default/files/The%20State%20of%20Asian%20and%20Pacific%20Cities%202015.pdf

10 Ibid.

11 Asian Development Bank (ADB), "Urban Poverty in Asia" (Philippines, September 2014). Available at https://www.adb.org/publications/urban-poverty-asia

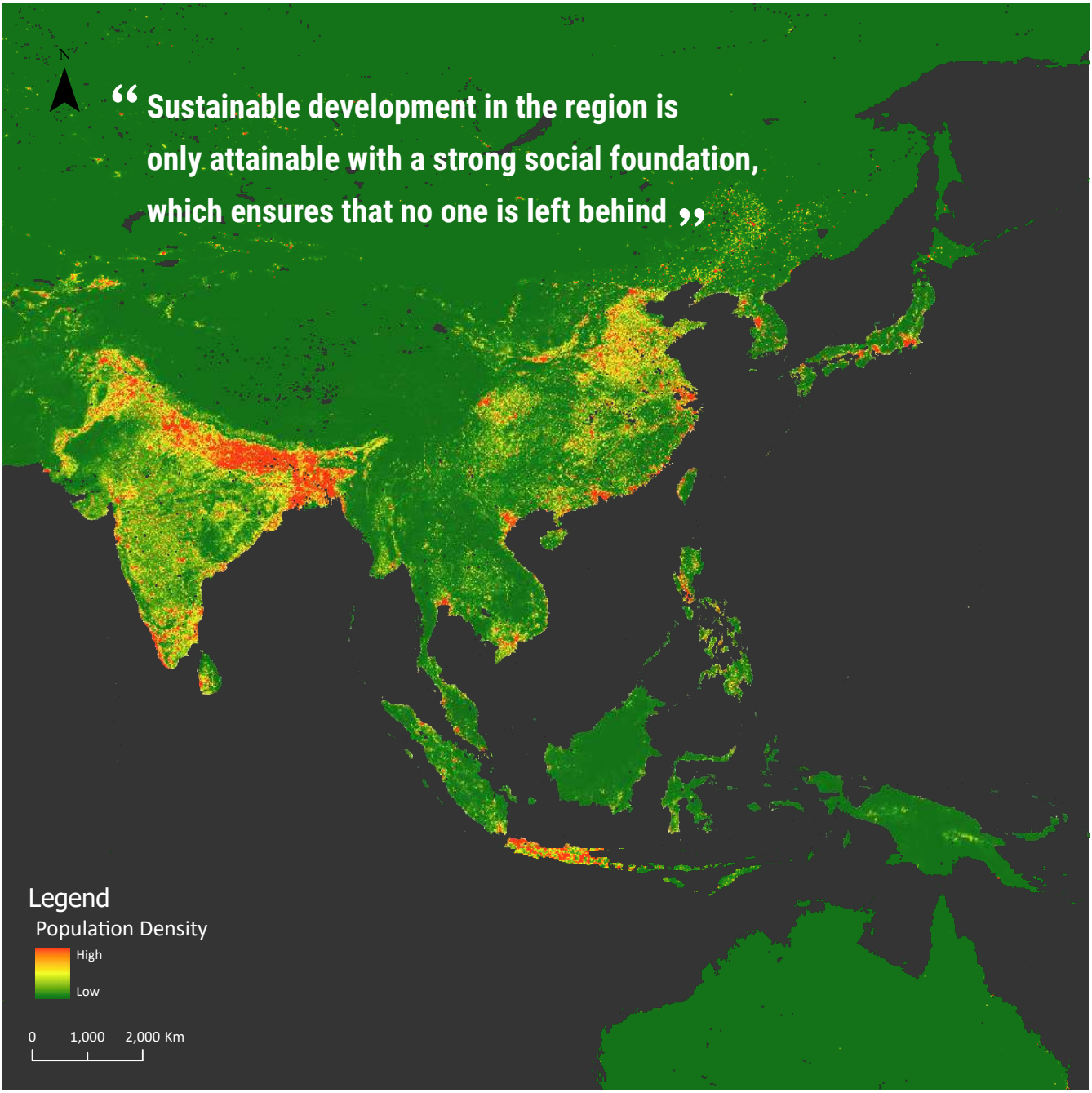
12 United Nations, Economic and Social Commission for Asia and the Pacific (ESCAP), UN-Habitat, "The State of Asian and Pacific Cities 2015: Urban transformations shifting from quantity to quality", 2015. Available at https://www.unescap.org/sites/default/files/The%20State%20of%20Asian%20and%20Pacific%20Cities%202015.pdf

13 Ibid.

14 Atlas of Urban Expansion. Available at http://atlasofurbanexpansion.org/

15 Marron Institute of Urban Management, "Urban Expansion". Available at https://marroninstitute.nyu.edu/programs/urban-expansion

Population density within the Asia-Pacific, 2020



Note: Estimated total number of people per pixel (grid-cell) at a resolution of 1km. Map developed by ESCAP. Data Source: WorldPop, 2020.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

In its initial phase, the programme focused on mapping and measurement of urban expansion globally. Using medium-resolution Landsat satellite imagery and census data, the overall urban extent of cities, the average population density of that extent, the fragmentation of the built-up area within it by open spaces, the compactness of its overall geographic shape, and the shares of infill, were mapped for three periods: circa 1990, circa 2000, and circa 2014 (Figure. 6.1). The second phase examined urban layouts and their development through time, by digitizing and analysing high-resolution Bing and Google Earth imagery for a representative sample of 30 cities. The final phase of the programme will incorporate land and housing survey data, presenting land ownership patterns, land-use planning practices, and the development of new subdivisions in the expanding areas of cities. In addition, data from affordability surveys will measure the prices, as well as the key attributes of different types of residential plots, houses, and apartments, that are available for sale or rent in the 200 cities in the global sample and compare them with household incomes in these cities.

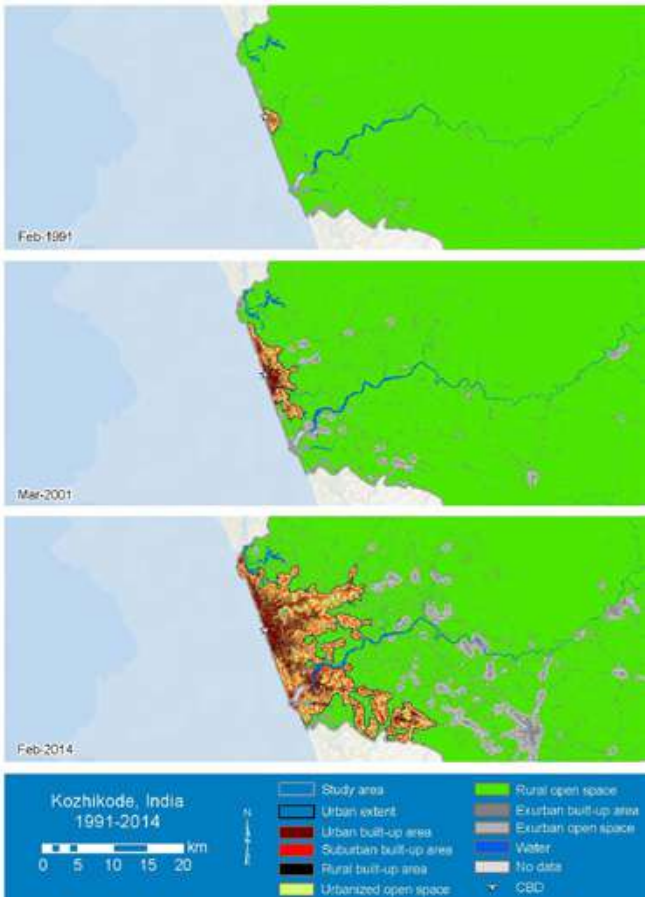
On its website, the Atlas of Urban Expansion presents the analysis results for the selected sample cities and offers access to the complete datasets. For instance, Figure 6.1 maps the urbanization of Kozhikode, India, while Figure 6.2 shows a sample of statistics compiled by the Atlas of Urban Expansion. According to the figures, Kozhikode, one of the fastest growing cities in the world,[16] had an average population growth rate of 7.6 per cent per year between 2001 and 2014.[17] Its urban built-up area had expanded even faster, at 14.6 per cent per year during the same period.[18]

[16] Niharika Sharma, "This Indian state headed for population de-growth also houses the world's fastest growing city", *Quartz India*, 8 January 2020. Available at https://qz.com/india/1781393/kerala-in-india-has-the-worlds-fastest-growing-city-by-population/

[17] Shlomo Angel and others, "Atlas of Urban Expansion" Vol. 1: Areas and Densities, NYU Urban Expansion Program at New York University, UN-Habitat, Lincoln Institute of Land Policy, 2016. Available at https://www.lincolninst.edu/sites/default/files/pubfiles/atlas-of-urban-expansion-2016-volume-1-full.pdf

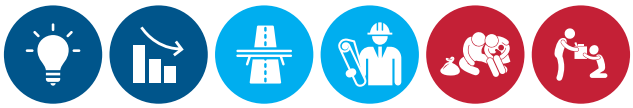
[18] Ibid.

Figure 6.1 Urbanization of Kozhikode in 1991 (Top), 2001 (Middle), and 2014 (Bottom)



Source: Shlomo Angel and others, "Atlas of Urban Expansion" Vol. 1: Areas and Densities, NYU Urban Expansion Program at New York University, UN-Habitat, Lincoln Institute of Land Policy, 2016. Available at https://www.lincolninst.edu/sites/default/files/pubfiles/atlas-of-urban-expansion-2016-volume-1-full.pdf
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

b. India: Odisha land title

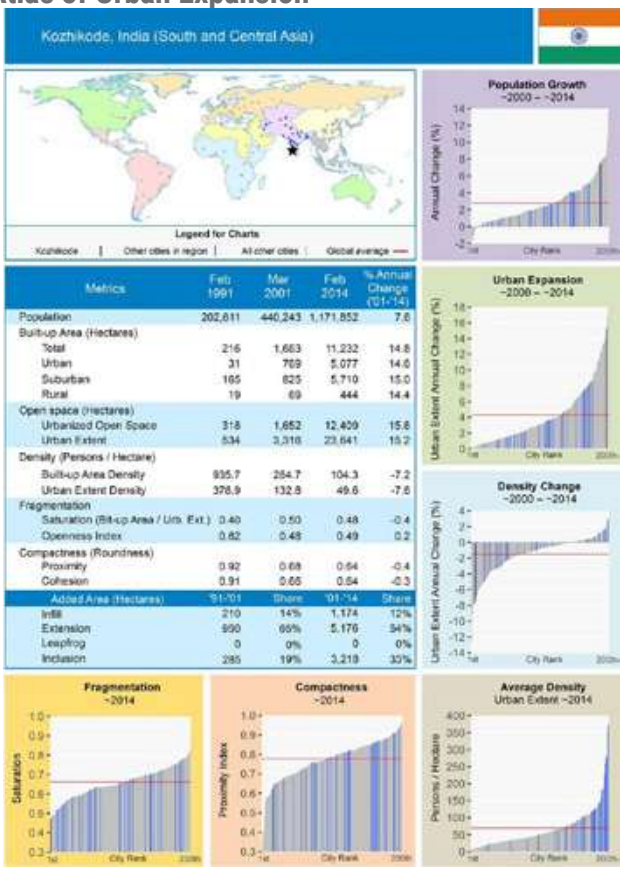


Slum upgrades become integral to improving the living conditions of the urban poor and for the general sustainability of cities. In 2020, the state of Odisha, in India, had decreased their slum population from 23.1 per cent, in 2011, to 3.72 per cent.[19] This huge reduction was due to the *Odisha Land Rights to Slum Dwellers Bill* that was passed by the state assembly in September, 2017.[20] The legislation pledged to issue a free Certificate

[19] "Odisha has lowest slum population in the country", *The Times of India*, 18 February 2020. Available at https://timesofindia.indiatimes.com/city/bhubaneswar/state-has-lowest-slum-population-in-the-country/articleshow/74181288.cms#:~:text=Bhubaneswar%20and%20Cuttack%20have%20the,22%25%20of%20the%20total%20population.

[20] Meera Mohanty, "Odisha government rolls out 'world's largest' slum land rights project", *The Economic Times*, 7 May 2018. Available at https://economictimes.indiatimes.com/news/politics-and-nation/odisha-government-roll-out-worlds-largest-slum-land-rights-project/articleshow/64068035.cms

Figure 6.2 Statistics of Kozhikode collected by Atlas of Urban Expansion



Metrics	Feb 1991	Mar 2001	Feb 2014	% Annual Change (01-14)
Population	202,611	440,243	1,171,852	7.6
Built-up Area (Hectares)				
Total	216	1,663	11,232	14.8
Urban	31	769	5,077	14.0
Suburban	165	825	5,710	15.0
Rural	19	69	444	14.4
Open space (Hectares)				
Urbanized Open Space	318	1,652	12,409	15.8
Urban Extent	534	3,316	23,641	15.2
Density (Persons / Hectare)				
Built-up Area Density	935.7	264.7	104.3	-7.2
Urban Extent Density	378.9	132.8	49.6	-7.6
Fragmentation				
Saturation (Bit-up Area / Urb. Ext.)	0.40	0.50	0.48	-0.4
Openness Index	0.82	0.48	0.49	0.2
Compactness (Roundness)				
Proximity	0.92	0.68	0.64	-0.4
Cohesion	0.91	0.65	0.64	-0.3
Added Area (Hectares)	'91-'01	Share	'01-'14	Share
Infill	210	14%	1,174	12%
Extension	990	65%	5,176	54%
Leapfrog	0	0%	0	0%
Inclusion	285	19%	3,219	33%

Source: Shlomo Angel and others, "Atlas of Urban Expansion" Vol. 1: Areas and Densities, NYU Urban Expansion Program at New York University, UN-Habitat, Lincoln Institute of Land Policy, 2016. Available at https://www.lincolninst.edu/sites/default/files/pubfiles/atlas-of-urban-expansion-2016-volume-1-full.pdf
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

of Occupancy of 30 square meters (320 square feet) to the economically disadvantaged, together with financial assistance up to Indian rupee 200,000 ($2,900), enabling homeowners to create permanent dwellings.[21] In summary, the Government of Odisha has undertaken the massive task of identifying, mapping, and issuing land titles for 2,000 slums and 1 million people.[22]

One of the major obstacles for granting land titles has been land record management. Even where land records exist, historical information can be inaccurate. With the assistance of technologies, such as GIS and high-resolution remote sensed imagery, such as drone imagery, the state of Odisha was able to digitalize and streamline its workflow for inventorying existing occupancy. The Government partnered with more than 27 local civil society organizations to collect data and capture imagery using drones.[23] In effect, taking advantage of space applications, the field teams achieved a high capturing rate of 200-250 households per day.[24] After seven months of drone surveys, Odisha was able to obtain high resolution maps for all 2,500 slums targeted by the initiative, becoming the first among all states in India.[25] These high resolution maps produced by drone imagery also bring accuracy and transparency to the process, helping the Government reduce the likelihood of large-scale disputes, litigation, and discontentment.[26]

The ownership of land title effectively lowered the risk of eviction for the Odisha slum dwellers.[27] The land titles pave the way for direct investments towards more permanent structures. This has also aided in disaster management as instead of spending money on rebuilding after the monsoon storms, the resources can now be assigned to permanent structures, such as roads, drainage, fresh water supply, toilets and sewers, streetlights, and common work sheds that can withstand wind and rain.[28]

[21] Brent Jones, "How one million people in India's Odisha slums gain land rights", *ESRI Blog*, 11 February 2019. Available at https://www.esri.com/about/newsroom/blog/how-one-million-people-in-indias-odisha-slums-gain-land-rights/

[22] Ibid.

[23] Ibid.

[24] Ibid.

[25] The University of Chicago, The Law School, "The Odisha Land Rights to Slum Dwellers Act, 2017, aka Mission Jaga", conversation with Mr. G. Mathi Vathanan, Principal Secretary, Department of Housing and Urban Development, Government of Odisha, India, 3 April 2019. Available at https://www.law.uchicago.edu/events/odisha-land-rights-slum-dwellers-act-2017-aka-mission-jaga-conversation-mr-g-mathivathanan

[26] Brent Jones, "How one million people in India's Odisha slums gain land rights", *ESRI Blog*, 11 February 2019. Available at https://www.esri.com/about/newsroom/blog/how-one-million-people-in-indias-odisha-slums-gain-land-rights/

[27] Ibid.

[28] Ibid.

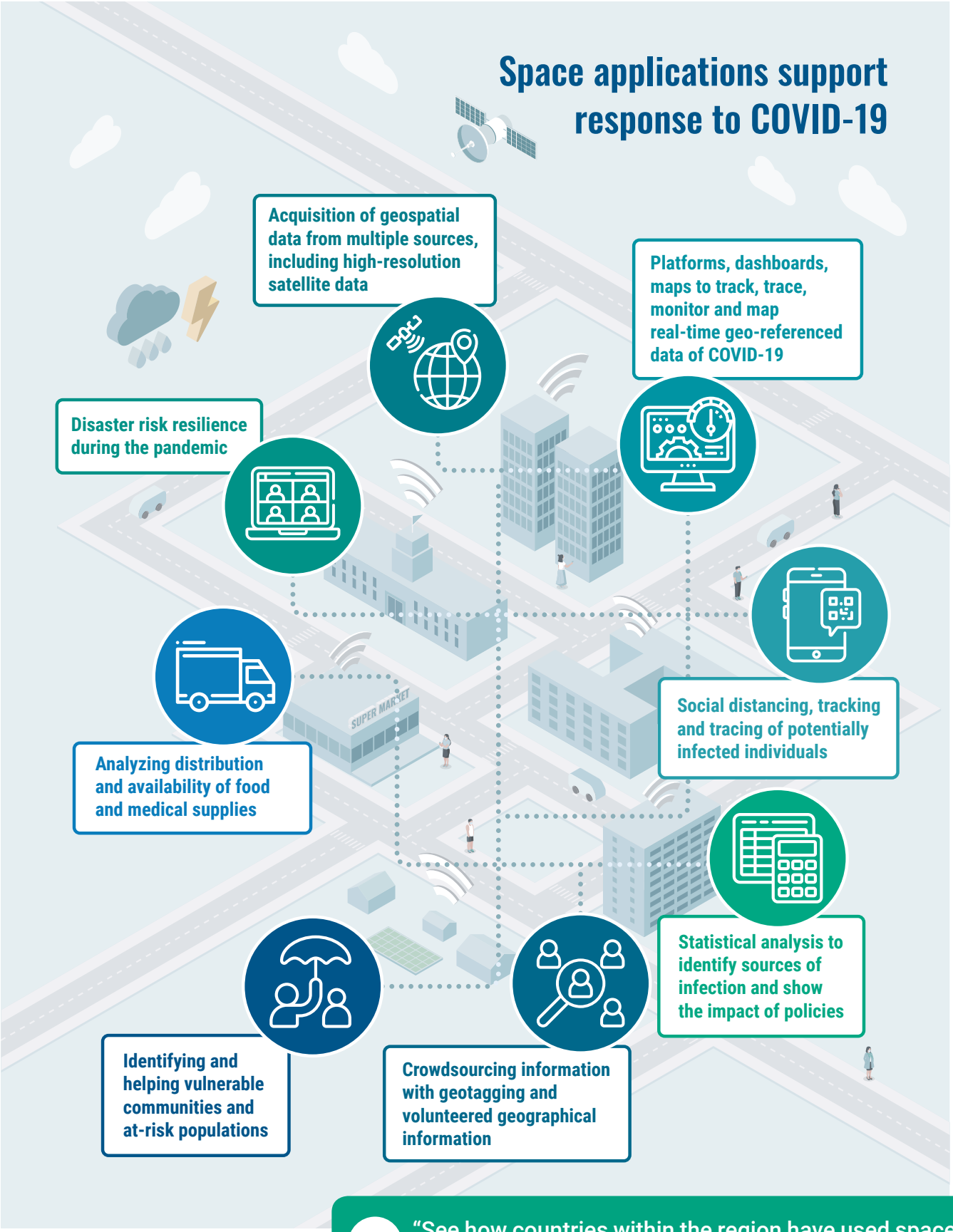
2. Health management: Monitoring, responding to, and preparing for COVID-19

Long before the COVID-19 pandemic hit, the drafters of the Plan of Action had the foresight to highlight the importance of strengthening the ability of countries in the Asia-Pacific region to leverage geospatial information for monitoring, responding to and preparing for pandemics. The Plan of Action requests the Secretariat and its Member States to research on how GIS, GNSS, Big Data analytics and mapping of health risk hotspots can contain the present and future spread of disease and pandemics, monitor health impacts, and promote cooperation to address transboundary health risks. The Plan of Action also identifies the need for research on tele-health solutions using space technology to improve emergency health capacities.

As the COVID-19 pandemic progresses, Governments around the world rely on measures, such as contact tracing, quarantining, and social distancing. All of these are spatial in nature and rely on geospatial information, digital solutions, and AI-driven risk analytics to enhance community resilience. Many countries have put in place geospatial information systems and have shown that hotspot mapping, contact tracing, and early warning systems open to public are all capable of strengthening the preparedness for COVID-19, as well as other disasters. These applications can also help in the recovery phase to build back better, by providing an evidence base for decisions on the easing of lockdown and the resumption of economic and social activities.

The pandemic has accelerated the research and capacity development on how geospatial information and Big Data can be used to map health risk hotspots and minimize the spread of health epidemics, which are action items set forth in the Plan of Action. For example, Governments are using geospatial data and space applications to support monitoring, response, and preparation for the COVID-19 pandemic. Public and private sectors have collaborated to develop platforms and publish information products, such as web maps of confirmed infections and deaths, maps of critical infrastructure and supplies, and available routes for medical staff, among others.

In support of these endeavours, ESCAP has prepared a guidebook on risk analytics and organized regional initiatives to advance the usage of geospatial applications for identifying vulnerable communities under the Asia-Pacific Disaster Resilience Network



"See how countries within the region have used space applications to work together to combat Covid-19."

(APDRN).[29] However, while measures involving geospatial information and Big Data have proven effective, it should be noted that the pandemic risks normalizing government use of invasive monitoring and surveillance systems with implications for the right to privacy.[30]

Space agencies in the region are providing Governments with vital location-based data, monitoring of key metrics and dashboards to facilitate decision-making. Countries with strong legal and regulatory geospatial frameworks and infrastructure, that already had systems and processes in place for collecting, managing and disseminating this kind of information were ahead of the curve. For example, the Korean National Spatial Data Infrastructure Portal allowed collaboration among various ministries, the police, telecommunication and other private companies.

[29] United Nations, Economic and Social Commission for Asia and the Pacific (ESCAP), "Socio-Economic Response to COVID-19: ESCAP Framework". Available at https://www.unescap.org/sites/default/files/ESCAP%20COVID-19%20Framework%20Paper.pdf

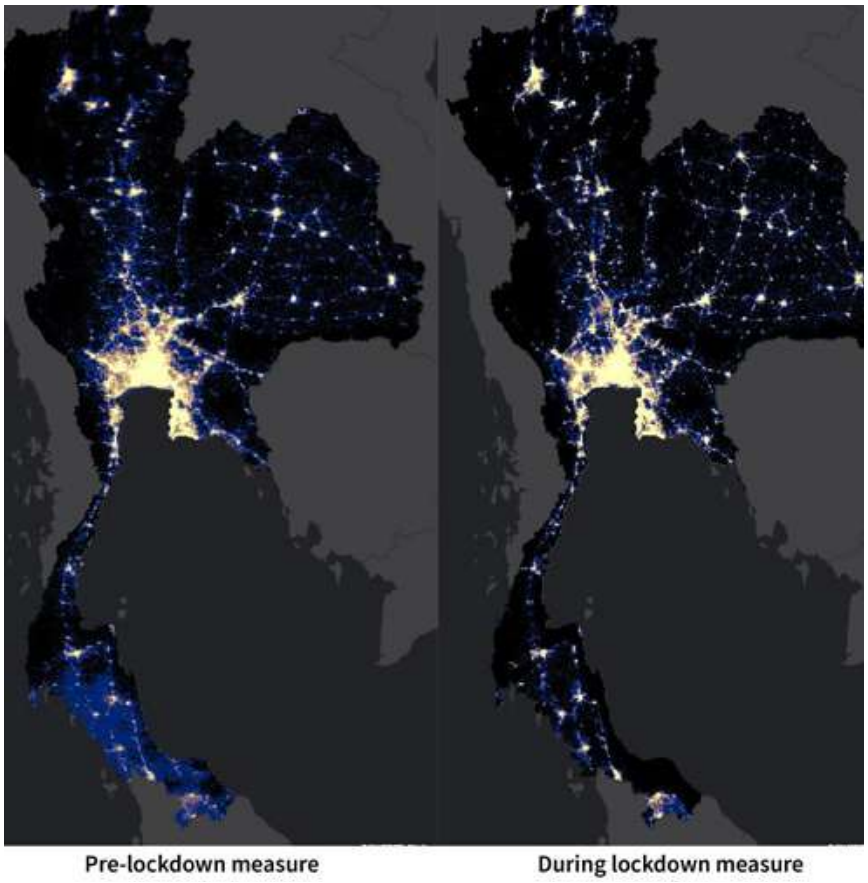
[30] See section on the importance of data safety and privacy in Chapter 10.

The following include an introduction to only a few of the many innovative examples of how space technology applications contribute to combatting the COVID-19 pandemic in the Asia-Pacific region.

a. Thailand: Lockdown measure impacts and COVID-19 iMAP dashboard

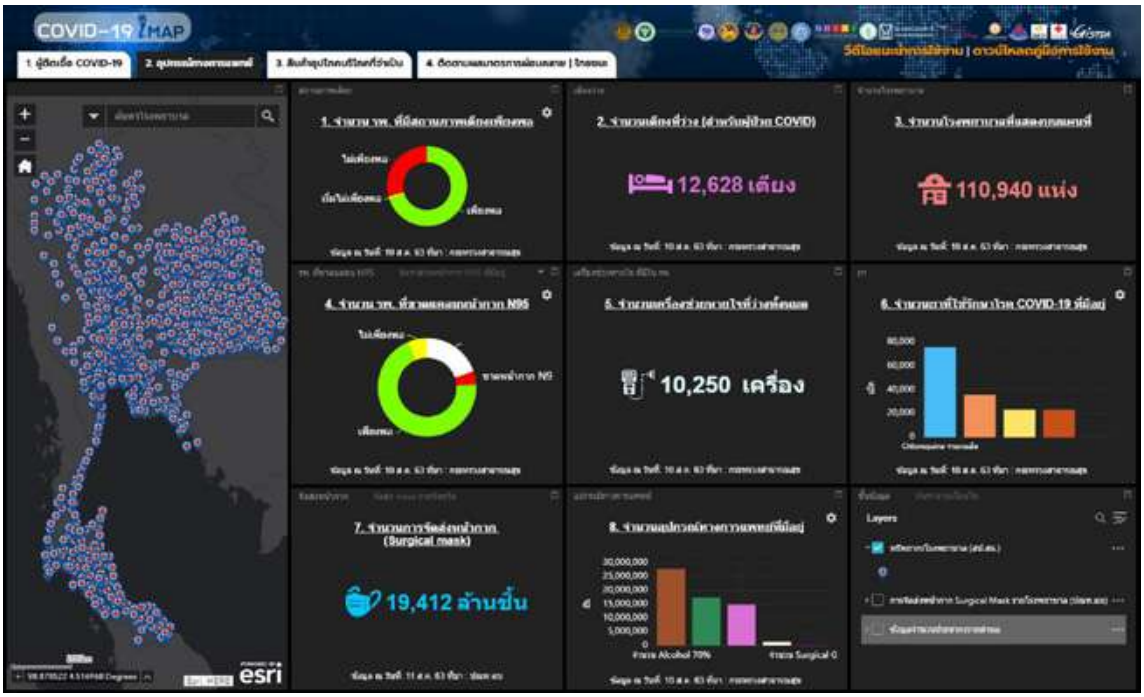
The Geo-Informatics and Space Technology Development Agency (GISTDA), in Thailand, used space applications to combat COVID-19, in particular to enable policymakers to utilize COVID-19 related data. GISTDA used space applications to monitor the COVID-19 situation and visualize the impact of the policies employed in the country. For example, GISTDA analysed reduced night-light images to monitor the impact from lock-down measures. A significant change can be seen in Figure 6.3 between the images from 3 December 2019 (pre-lockdown) and 20 April 2020 (post-lockdown measures).

Figure 6.3 Reduced night light image of Thailand before and during the COVID-19 pandemic lockdown



Source: GISTDA
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Figure 6.4 COVID-19 iMAP dashboard, developed in Thailand



Source: GISTDA
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Furthermore, GISTDA used satellite data to monitor nitrogen dioxide emissions and found that since the beginning of the year, most provinces in Thailand had less activities that caused emissions. These examples are some of the many sources of data for monitoring that were reported to the Thai Government.

Additionally, to support the Working Group on Data Integration and Analysis for the COVID-19 Situation, GISTDA developed a dashboard to integrate data so it can be summarized and linked to maps. This was useful for specific users, such as policymakers, and those in the field, in order to enable them to monitor the pandemic situation, medical capacity and supplies, consumer goods, and preventive and precautionary measures (Figure 6.4).

b. Indonesia: Heatmaps of vulnerability levels

The National Institute of Aeronautics and Space of Indonesia (LAPAN) developed a data hub in April 2020 to perform regional-level risk assessment and visualization on COVID-19. The applied risk assessment methodology measured COVID-19 data with an integrated system of multi-level indicators and formulas. With additional data gathered from multiple geospatial and statistical sources.

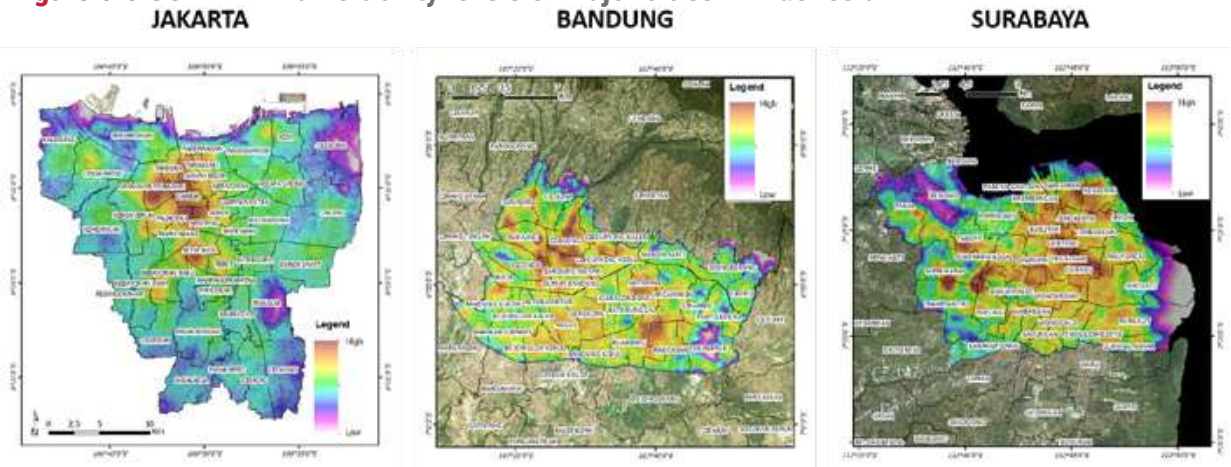
The major challenge for LAPAN was to automatically obtain daily COVID-19 statistical data in digital formats, as some statistics were available only for district and village levels. LAPAN made use of geospatial tools, such as ESRI's ArcGIS Hub coronavirus response template, linked with the COVID-19 National Task Force, which is managed by the National Disaster Management, in order to address the challenges. LAPAN was able to develop a formula of data mining that incorporated mid, high and very high-resolution satellite data combined with statistics for determining the potential risk of COVID-19 spread.

Indonesia is among the countries that are applying geospatial techniques to generate 'heatmaps' for those communities that are vulnerable to the impacts of COVID-19, and to locate the poorest people who are left out of social protection systems. By combining geo-referenced aggregated data and artificial intelligence, this deepens the understanding of the impact of COVID-19 for better pandemic preparedness in the future.

c. India: Bhuvan-COVID-19

The Government of India and its state governments have taken several steps to contain the COVID-19

Figure 6.5 COVID-19 vulnerability levels of major cities in Indonesia



Source: National Institute of Aeronautics and Space of Indonesia (LAPAN)
Note: Vulnerability levels are calculated using the Zone of Population Density and Settlement, the Zone of Density of Road Access Conditions and the Zone of Strategic Locations against COVID-19 spread.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

pandemic. ISRO has assisted in this by providing and leveraging geospatial tools, in particular BHUVAN – the Indian Geo-Platform.[31] The geospatial information platform provided service in six aspects: tracking, identifying hotspots, vegetable markets, food needed, home isolation and pollution. Additionally, as India needed a dashboard to better understand the current circumstances in the country, ISRO customized the Geo-portal and developed 'Bhuvan-COVID-19' at a national level to track the pandemic and update the public on the current situation.

d. Fiji: Dashboard and managing disasters during COVID-19

Fiji's Ministry of Lands and Mineral Resources Geospatial Information Management team set up the geospatial capability within the Ministry of Health and Medical Services Incident Management Team for COVID-19, one week prior to the first reported case. The team has been working with the Incident Management Team ever since using ArcGIS and their geospatial datasets to combine data. This includes data on contact tracing, fever clinics, isolation facilities and cluster information to provide situation reports in order to assist with the planning and deployment of resources for the health teams. The Geospatial Information Management team also worked with Fiji's Military Forces to assist them in using geospatial resources for their security planning and relief efforts.

[31] See Bhuvan section in Chapter 3, *Land-use management*.

Additionally, the team developed a dashboard that integrated information from multiple data sources that supported decision-making.[32] The team's work also promoted disaster-risk resilience in the crisis. On 7 April 2020, when Tropical Cyclone Harold devastated parts of Fiji, once again geospatial information proved to be very useful in identifying the affected communities and for the deployment of relief assistance to these communities.

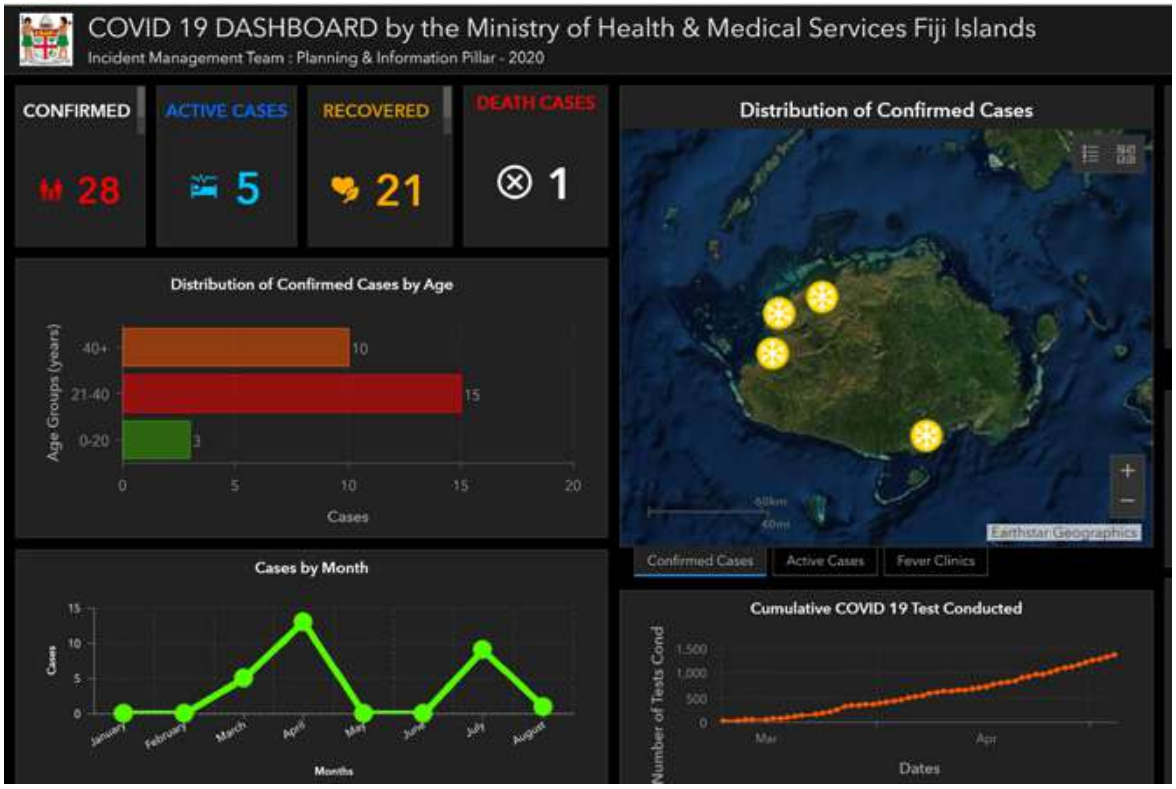
e. Malaysia: WebGIS dashboard

The Department of Survey and Mapping Malaysia developed a WebGIS dashboard application that provides a Geospatial Common Operating Picture for the National Security Council and the Malaysian Armed Forces on the latest development of COVID-19. This includes reporting of positive cases among people under surveillance, both within the National Security Council and Malaysian Armed Forces communities, as well as the public. The dashboard is equipped with a display containing the attribute and geospatial information and was used as one of the main monitoring platforms of the pandemic.[33] This dashboard is a key tool that has provided insight and timely information for decision makers to plan and execute operations under the country's Movement Control Order, and to deploy security forces, including

[32] Fiji COVID 19 Dashboard. Available at http://fijigeospatial.maps.arcgis.com/apps/opsdashboard/index.html#/a099962e2cae4e15b8127d044753723d

[33] Bernama, "COVID-19: Ketsa develops application for ATM and MKN", *Astro AWANI*, 10 April 2020. Available at http://english.astroawani.com/malaysia-news/covid-19-ketsa-developsapplication-atm-and-mkn-237644

Figure 6.6 Fiji COVID-19 Dashboard



Source: Ministry of Health & Medical Services Fiji. Available at http://fijigeospatial.maps.arcgis.com/apps/opsdashboard/index.html#/a099962e2cae4e15b8127d044753723d
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

for cordoning off affected areas and maintaining roadblocks. It also incorporates the Government's analytical tools to empower descriptive, diagnostic, predictive and prescriptive analysis of the outbreak.

f. China: Health QR codes

To respond to the COVID-19 outbreak, Hangzhou, China, launched the Big Data health QR code platform to manage the influx of population after the Chinese New Year in spring 2020.[34] People can use Alipay, WeChat and other popular mobile applications to submit their personal health status, including whether they have been in contact with confirmed or suspected patients within the last 14 days, and if they have had any symptoms. Based on this self-reported information, each person would be assigned a QR code with a colour indicator (Green: healthy; Yellow: need 14-day quarantine; Red: need treatment and quarantine). Inspired by Hangzhou, other cities and provinces launched their own health code and the national Government followed suit by launching the national service platform for health QR code on 29 February 2020. As a result, the health QR code has become available for cross-province recognition. The platform is now connected to real-time information databases, such as a dynamic name list of confirmed or suspected patients and a local community risk database that evaluates users' real health status automatically and intelligently. The health QR code platform has achieved efficient crowd control, improved the efficiency of inspection in crowded places, such as office buildings, shopping malls, and railway stations, and minimized direct contacts.

g. Philippines: Campaign supports innovative apps

In the Philippines, the response to COVID-19 has greatly benefited from the Government's partnership with the private sector and academic institutions. The Department of Science and Technology – Philippine Council for Industry, Energy and Emerging Technology Research and Development (DOST-PCIEERD) called

[34] Paul Mozur, R. Zhong and A. Krolik, "In Coronvirus fight, China gives citizens a color cold, with red flags", *The New York Times*, 1 March 2020. Available at https://www.nytimes.com/2020/03/01/business/china-coronavirus-surveillance.html

for proposals from individual and institutional initiatives, through its "Geoinformation Solutions to COVID-19 and the Community Quarantine" campaign, which began as early as 19 March 2020. Multiple projects utilizing geospatial information for COVID-19 have been put into operation as a result.

The University of Philippines, Diliman Department of Geodetic Engineering proposed the "Tracking for Allocation of Medical Supplies (TrAMS)", which is an online geographic system for tracking information regarding medical resources in health facilities. Reliant on volunteered and crowdsourced information, this system provided necessary support for the proper allocation of medical resources, which was needed by the healthcare facilities.

The Ateneo de Manila University developed the Feasibility Analysis of Syndromic Surveillance using Spatio-Temporal Epidemiological Modeler (FASSSTER) for early detection of diseases. To adjust this tool for COVID-19, FASSSTER underwent a series of enhancements, including disease models and a self-reporting mechanism, for better ability to project the effects of interventions and the number of cases.

Other geospatial-enabled tools include contact tracing systems "BirdsEye" by the University of San Carlos, the infection tracker "Barvid-19" developed by students from the Technological Institute of the Philippines, and a Big Data analytics product by the De La Salle University, that supported traffic management during the Philippine enhanced community quarantine.

h. The Republic of Korea: Private sector's role in developing vital platforms

Esri Korea has been updating the COVID-19 status of Seoul via ArcGIS. It managed to leverage Geospatial mapping to tackle the COVID-19 crisis. Not only does it provide the number of confirmed cases according to each province of Seoul, but also provides very detailed information of each person who was infected and the quarantine status of buildings and areas. Both the Esri website and Seoul COVID-19 website is accessible via smartphone.

Furthermore, a small software company, in the Republic of Korea, has established a map to analyse the path of new coronavirus patients. In addition to the existing map data, Intra map received information from the National Geographic Information Institute, the Korea Local Information Research and Development Institute, and the Korea Centers for Disease Control and Prevention. Through collaboration and collective intelligence, the Republic of Korea was able to establish a map of the path analysis of new corona confirmed patients in real time.

The Government of the Republic of Korea released the sales data for masks to the public using open application programming interface (API), encouraging developers to create apps that notify the inventory status of pharmacies carrying masks nationwide, in order to reduce queues and the shortage of masks. Around 22,000 of the 23,000 pharmacies nationwide that sold masks agreed to hand over their data.

COVID-19 response: Conclusion

Certainly, these examples are not exhaustive, but illustrate how space and geospatial information applications have played an important role in providing essential location-based and temporal data to make an overall data map and status snapshot on the COVID-19 pandemic for policymakers and the public. Regional cooperation will help the Governments to operate a comprehensive platform in order to better integrate various data and information, including satellite-derived data and ground geo-referenced data, in response to the COVID-19 pandemic, although the structure of the platform used by Governments vary from country to country. Despite good progress in several countries in Asia and the Pacific, there are many challenges that remain on data integration, such as rapid data collection and integration, link with policy implementation and action, data privacy, and cooperation with the public on data collection and access.

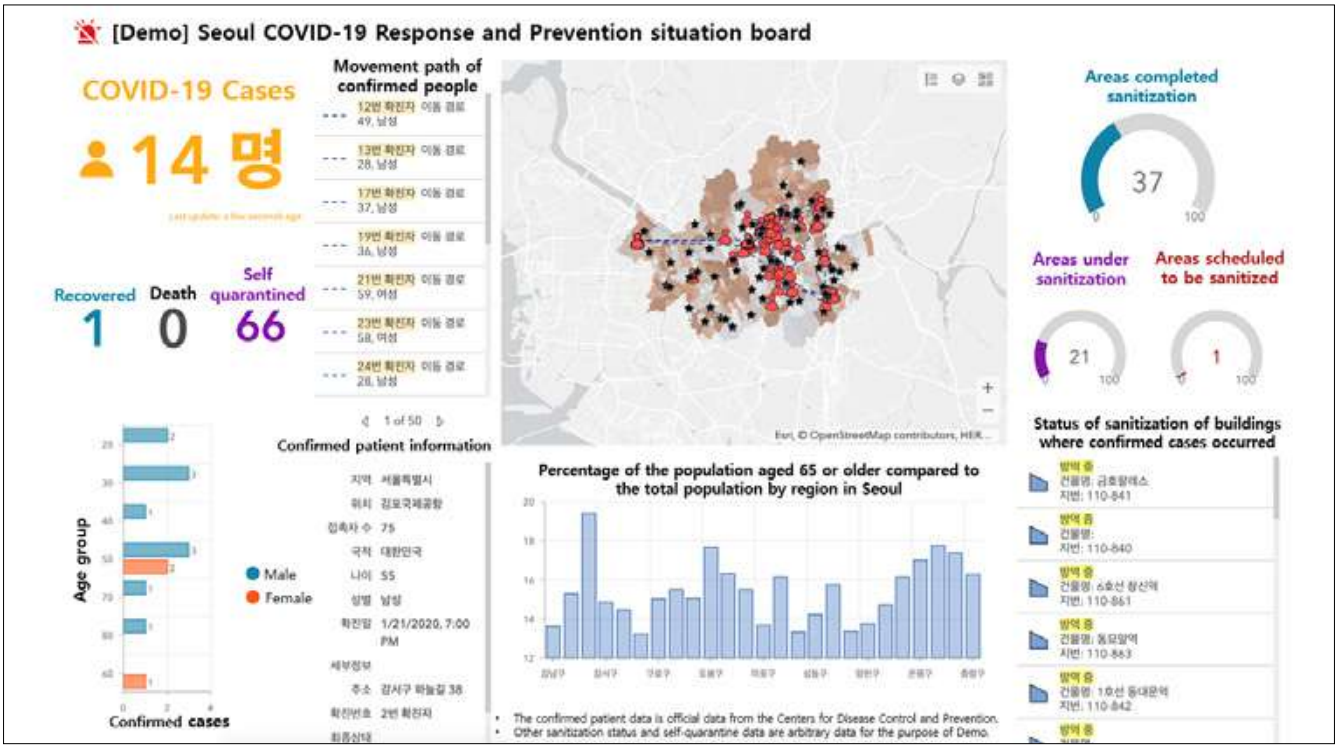
3. Contamination and pollution

Air pollution is the fifth leading risk factor for mortality and was estimated to have contributed to approximately five million deaths globally.[35] Although countries and cities have implemented various air pollution management policies, these will only offset the additional pollution produced by a growing population and by urbanization.[36] In 2018, Asia and the Pacific was home to 96 of the 100 cities most

[35] Health Effects Institute (HEI), "State of Global Air 2019: Air pollution a significant risk factor worldwide", June 2019. Available at https://www.healtheffects.org/announcements/state-global-air-2019-air-pollution-significant-risk-factor-worldwide

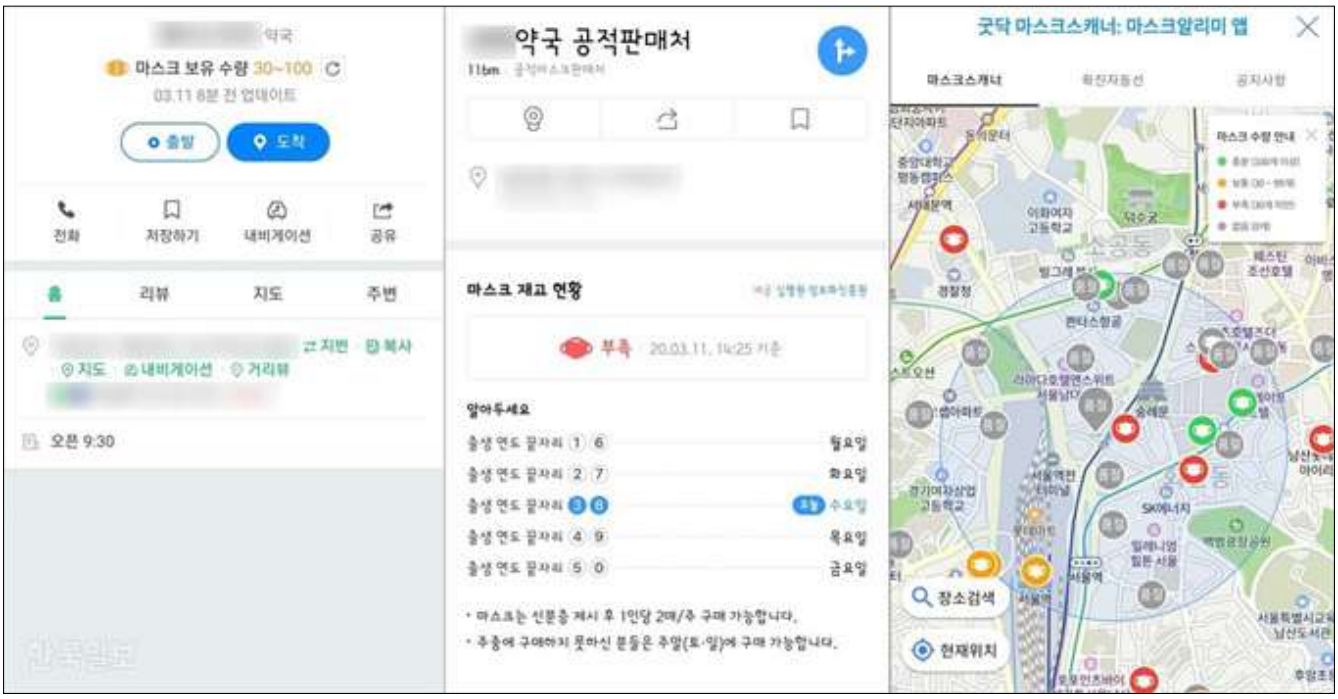
[36] Climate and Clean Air Coalition (CCAC) and United Nations Environment Programme (UNEP), "Air pollution in Asia and the Pacific: Science-based solutions", 2019.

Figure 6.7 Esri Korea COVID-19 response and prevention dashboard



Source: ESRI. Available at https://www.arcgis.com/apps/opsdashboard/index.html#/f8c2df1b8dfb4b288e6db2f824ce4d45, Translated into English by Taeook Kang.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Figure 6.8 Mask inventory application

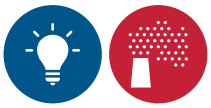


Source: Images available at https://m.hankookilbo.com/News/Read/202003111513096264
Note: The applications are Naver map (left), Kakao map (centre), Goodoc (right)
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

polluted with fine particles (PM2.5).[37] More work is needed to implement evidence-based, effective solutions for long-term air pollution risk.

The monitoring of air quality has been mainly based upon in-situ measurements by Governments using ground-based air quality monitoring networks within their territories. However, ground-based monitoring has limitations, since monitoring stations are mostly concentrated in densely populated cities with rigid installation requirements and very narrow spatial coverage. Air pollution monitoring stations are often based in urban areas, yet pollutants can be generated elsewhere or travel great distances and affect not only rural areas but other countries as well. Satellite observations complement the ground-based networks by providing data over wider areas, which is particularly useful for regions where no surface monitors are installed, such as rural areas or countries with limited air pollution monitoring equipment or capacity. This satellite information will help evaluate and improve air quality and chemical transportation models, emissions inventories and allow the production of timely air pollution forecasts which will be accessible to everyone through a broad range of platforms and applications. Over the long term, the effectiveness of policy interventions can be monitored. For the short-term, pollution hotspots missed by emission inventories or ground monitoring stations can be identified and addressed. This data can fill in information gaps left by ground-data collected through monitoring stations to help evidence-based policy making to address not only national and local air quality, but transboundary pollution issues.

a. Republic of Korea: Geostationary Environment Monitoring Spectrometer (GEMS)



The Geostationary Environment Monitoring Spectrometer (GEMS), launched by the Republic of Korea in February 2020, enables the hourly monitoring of air pollution levels for almost 20 countries in Asia. Specifically, countries covered by the project include Cambodia, the Lao People's Democratic Republic, Malaysia, Myanmar, Philippines, Singapore, Thailand, Viet Nam (ASEAN); Bangladesh, Bhutan, Nepal and Sri Lanka in South Asia; and China, Japan and the Republic of Korea in North-East Asia. The satellite also covers parts of India, Indonesia, Kazakhstan, Kyrgyzstan, Mongolia, Papua New Guinea, the Russian Federation and Tajikistan.

GEMS is the first satellite to launch in an integrated three satellite constellation, in order to revolutionize the way scientists observe air quality over significant swaths of the Northern Hemisphere. While GEMS will monitor atmospheric gases over Asia, TEMPO will monitor North America, and Sentinel-4 will observe the air quality over Europe. This marks a significant leap forward in the ability of scientists to monitor air pollution from space. The regular measurement of O_3 and its precursors NOx and volatile organic compounds, along with particulate matter, SO_2 and other pollutants, will improve the accuracy of air quality forecasts, top-down emission rates and understanding on the long-range transport of air pollutants.

b. Thailand: Space and geospatial information for air pollution monitoring

Thailand and neighbouring countries share severe cross-border haze problems resulting from PM2.5. The impacts on resources, environment, economy, society, transportation, and health have been acute. In response to these impacts, GISTDA established a haze monitoring system using geo-informatics technology that integrates data from multiple resources. This system continuously monitors and examines the haze situation nationwide. The information collected by the system will provide important assistance to the management of pollution, and eventually help reduce the sources of haze. The major products of the haze-monitoring system include:

Hotspot maps (Figure 6.9) organized and based on the types of haze source locations: conservation forests, reserve forests, agricultural areas, highway areas, community areas, and others. The data include the direction of the haze and its distance from the nearest villages.

Daily haze map, PM2.5 map, and PM10 map (Figure 6.10) that shows the diffusion of haze, including information such as air quality from the Pollution Control Department. Local people and agencies can access the map to protect themselves.

Map of forest fire risk area, which is produced from the analysis of meteorological data, land use, Normalized Difference Vegetation Index (NDVI), Normalized Difference Water index (NDWI), and cumulative heat

[37] IQ Air, "World's most polluted cities 2019 (PM2.5)". Available at https://www.airvisual.com/world-most-polluted-cities

spot statistics of burning area. The map supervises forest patrols in choosing surveillance points, increasing their management efficiency and helping to reduce combustion areas.

c. Viet Nam: Pollution and contaminated sites assessment

Earth Observation for Sustainable Development (EO4SD) is a new initiative from the European Space Agency (ESA) to increase the uptake of satellite-based information in the International Financial Institutions (IFIs)' programmes. EO4SD-Fragility, Conflict, and Security was part of United States Agency for International Development (USAID)'s project, "Environmental Assessment of Dioxin Contamination at Bien Hoa Airbase, Viet Nam".[38] The airbase is a key dioxin contamination hotspot due to past usage, storage, and handling of various types of herbicides during the Viet Nam War. The project aims to provide guidance for the airbase to address this contamination in the future. EO4SD-Fragility, Conflict, and Security helped in identifying pollution and contaminated sites through the analysis of Earth Observation data and supporting information. Using satellite data, elevation and drainage data, and the historical records of contaminant use and handling, EO4SD delivered products, including Conceptual Site Models and Site Characterization in standard GIS format.

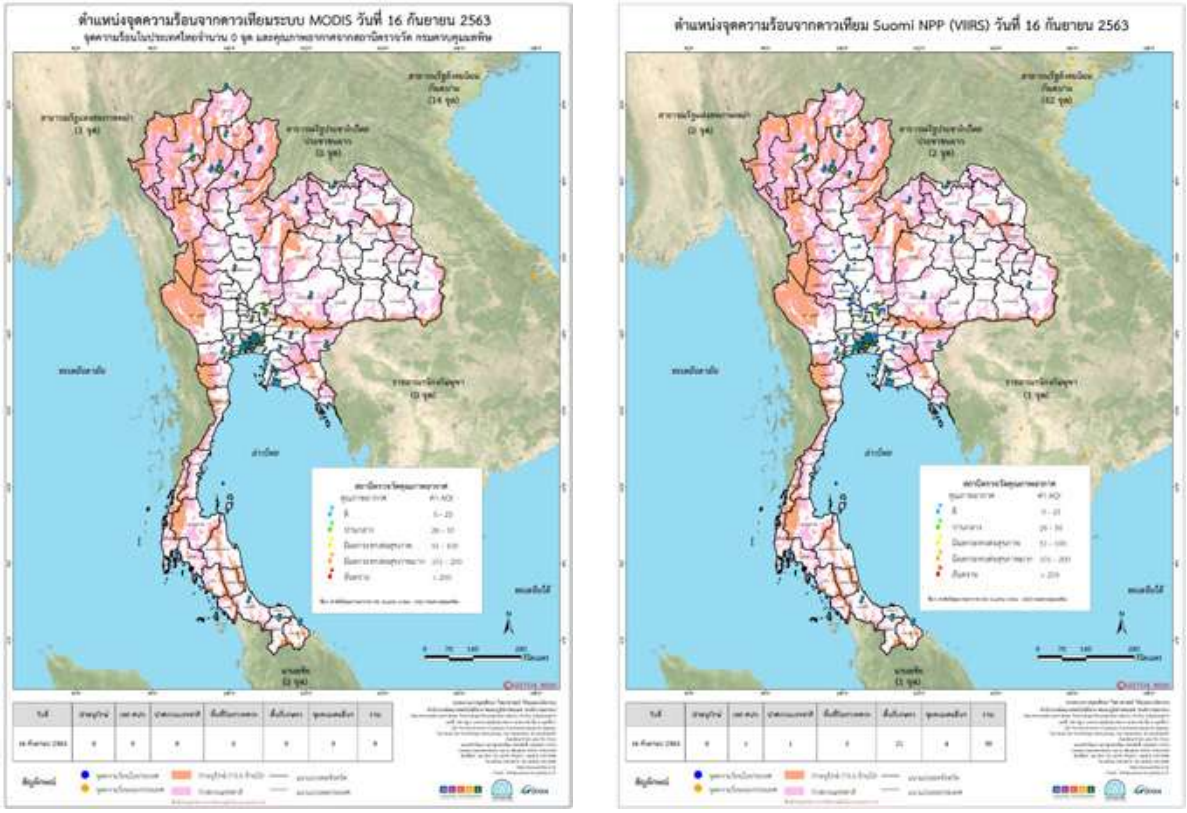
4. Knowledge aggregation and evidence building

Among the six thematic areas stipulated by the Plan of Action, social development is the most human-centred, with targets being directed toward people who have been left behind, particularly the 400 million people living in extreme poverty.[39] Thus, to design a new response or evaluate an existing response to social development challenges, policymakers need to equip themselves with a clear understanding of

[38] USAID Viet Nam, "Environmental Assessment of Dioxin Contamination at Bien Hoa Airbase". 3 May 2016. Available at https://www.usaid.gov/sites/default/files/BH-Final-EA-2016-05-03_EN-reduced.pdf

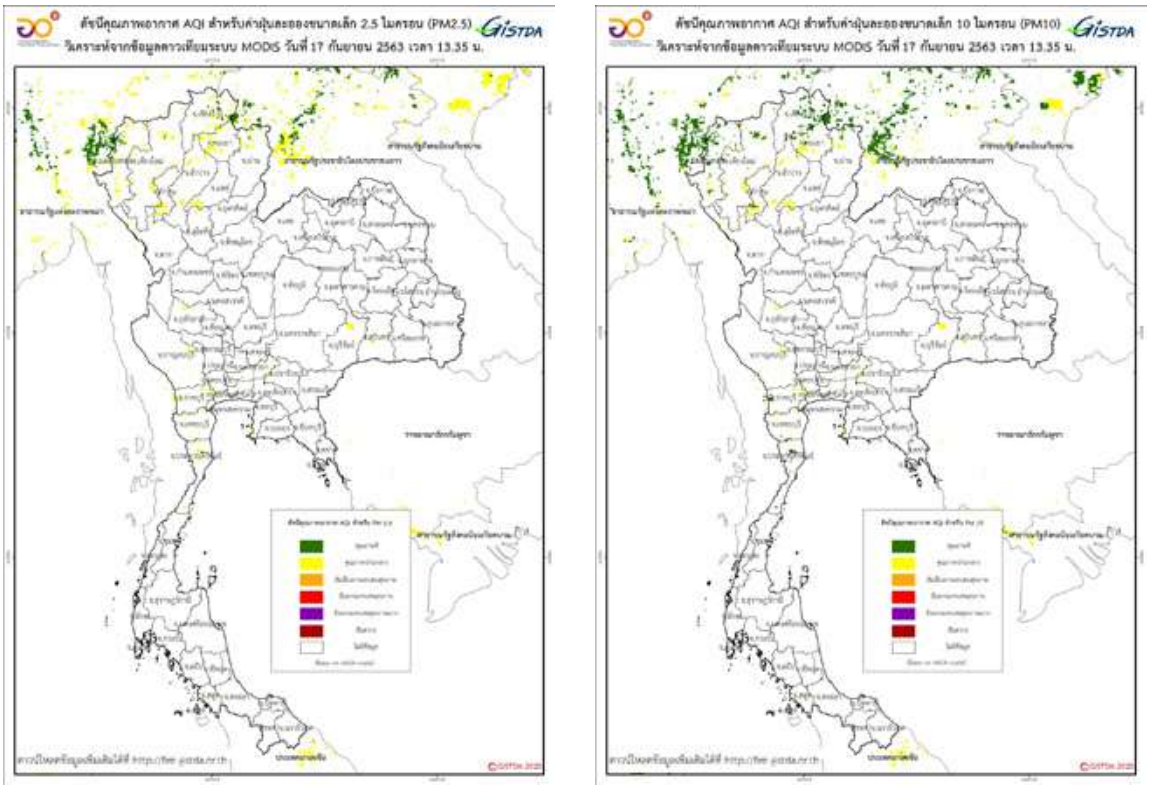
[39] *Sustainable Social Development in Asia and the Pacific: Toward a People-Centred Transformation* (United Nations publication, Sales No. E.17.II.F.15). Available at https://www.unescap.org/sites/default/files/publications/Sustainable%20Social%20Development%20in%20A-P.pdf

Figure 6.9 Daily Hotspot Maps from MODIS (left) and VIIRS (right)



Source: GISTDA, Download the daily forest fire situation information. Available at http://fire.gistda.or.th/download.html (accessed on 17 September 2020)
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Figure 6.10 Daily Maps of PM2.5 (left) and PM10 (right) for Thailand



Source: GISTDA, Download the daily forest fire situation information. Available at http://fire.gistda.or.th/download.html (accessed on 17 September 2020).
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

the experiences of the target populations. To achieve this understanding it requires two levels of knowledge aggregation: macro-level monitoring, that measures indicator statistics, and micro-level profiling, that extracts local knowledge and crowd-sourced data from first-hand experiences.

Geospatial information and space applications are helpful for both macro- and micro-level monitoring. With the increased capacity of Earth observation and satellite technologies, monitoring hazards, such as pollutions and contamination is now more practical and efficient; with advanced mapping tools local knowledge can be organized into geo-referenced data, allowing more intuitive access. The following examples demonstrate these applications in action.

a. The 'Know Your City' Initiative

Know Your City,[40] is a global initiative jointly organized by Slum Dwellers International, United Cities and Local Governments of Africa, and the Cities Alliance. In this initiative, slum dwellers around the world play a key role in producing and aggregating local knowledge. The involvement of members of the community in the profiling process creates a dialogue and helps identify the most pressing issues, ensuring the local voice is heard. Settlement profiles are created by collecting baseline data of settlements through general surveys gathering information on demographics, shelter, access to basic services, and community development priorities. Classic survey methods, such as household-by-household census, were successively enhanced through addition of technologies, such as cell phones, portable GPS devices, aerial and remote photography, to complement mapping and data collection.[41]

As of 2020, the initiative profiled over 7,700 slums in 224 cities in close collaboration with slum dweller communities. On its website, the Know Your City initiative offers access to the collected datasets with a wide range of information on these settlements, including sanitation, water, infrastructure, community organization, health access and commercial facilities. This database serves as a repository of informal

[40] Slum Dwellers International (SDI), "Know your city". Available at https://knowyourcity.info/

[41] Slum Dwellers International (SDI), "Know Your City: Slum Dwellers Count", 2018. Available at https://knowyourcity.info/wp-content/uploads/2018/02/SDI_StateofSlums_LOW_FINAL.pdf

settlement data in the world and supports the work of researchers, policymakers, local governments and national Governments. In the covered cities, organized slum dwellers have produced data in a participatory, people-centred way to anchor constructive dialogue with the local government and action is aimed toward leaving no one behind.

In its Asia hub, the Know Your City initiative has been able to complete the settlement profiling and boundary mapping of over 120 settlements across Bangladesh, Cambodia, Indonesia, Myanmar and the Philippines.[42] For instance, the initiative finished profiling the slum settlement Busvhai located in Davao, Philippines, in June 2019. A well-organized sample of information on Busvhai's land use, local services, and infrastructures are presented on the Know Your City website. Furthermore, the initiative has conducted training workshops to support the citywide information collection and GIS map preparation in all five countries, ensuring that data collection activities are contextualized within the larger context of Slum Dwellers International objectives for pro-poor city transformation.[43]

b. Kathmandu Valley, Nepal: Heritage mapping and modelling

The 2015 Gorkha 7.8 magnitude earthquake impacted over 2900 heritage structures in Kathmandu Valley, Nepal, with 700 structures damaged and 131 completely destroyed.[44] Due to a lack of surveying data, and limited contribution from aerial imagery, the restoration has been challenging.[45] Being a country whose national economy depends heavily on heritage driven tourism, which supported more than one million jobs, Nepal suffered from the loss of cultural heritage in this earthquake.[46] As a result, a series of efforts have begun to address the issue of heritage protection. This includes workshops for 3D and virtual reality modelling,[47, 48] to use photogrammetry and VR technology to bring Nepali heritages to life and the Share Our Cultural Heritage (SOCH) platform,[49] which uses photogrammetric modelling to reconstruct heritage structures or artefacts into 3D digital models. These are then visualized on an open-access website or mobile app.

Additionally, the Nepal Heritage Documentation Project,[50] documents the vulnerable physical cultural heritage and buildings in Nepal, using a new Digital Archive of Nepalese Arts and Monuments, which provides an easy access to Nepali heritages from a map-based portal.[51]

c. China: Local monitoring of sustainable development in Deqing County

Cross cutting to multiple SDGs and sub-themes.

A systematic review to track the progress of sustainable development presents technical and coordination challenges, such as the selection of appropriate indicators, the availability of reliable data sets, and the cross-cutting relationships between many SDGs.[52] To explore the solutions to these challenges, China has run a pilot project for monitoring local progress towards the SDGs in Deqing county, Zhejiang province. The National Geomatics Center of China led a team of 20 researchers who conducted quantitative assessments based on fine-scale population data over the 938-square-kilometre county (Figure 6.12).[53, 54]

42 Slum Dwellers International (SDI), SDI Annual Report 2018-2019. Available at https://knowyourcity.info/wp-content/uploads/2019/09/SDI-Annual-Report-2018-2019.pdf

43 Ibid.

44 H.K. Dhonju and others, "Share our cultural heritage (SOCH): Worldwide 3D heritage reconstruction and visualization via Web and Mobile GIS", *International Journal of Geo-Information*, vol. 7, No. 9 (2018). Available at http://eprints.whiterose.ac.uk/144560/

45 Ibid.

46 Sangam Prasin, "Nepal tourism generated Rs 240b and supported 1m jobs last year: Report", *The Kathmandu Post*, 27 May 2019. Available at https://kathmandupost.com/money/2019/05/26/nepal-tourism-generated-rs240b-and-supported-1m-jobs-last-year-report

47 Justin Eure, "Preserving Nepal's sacred sites with stunning 3D models", *Lenovo StoryHub*, 7 May 2019. Available at https://news.lenovo.com/rendering-nepals-sacred-sites-in-stunning-3d/

48 Ibid.

49 H.K. Dhonju and others, "Share our cultural heritage (SOCH): Worldwide 3D heritage reconstruction and visualization via Web and Mobile GIS", *International Journal of Geo-Information*, vol. 7, No. 9 (2018). Available at http://eprints.whiterose.ac.uk/144560/

50 Heidelberg Centre for Transcultural Studies, "Partners". Available at http://www.asia-europe.uni-heidelberg.de/index.php?id=4400

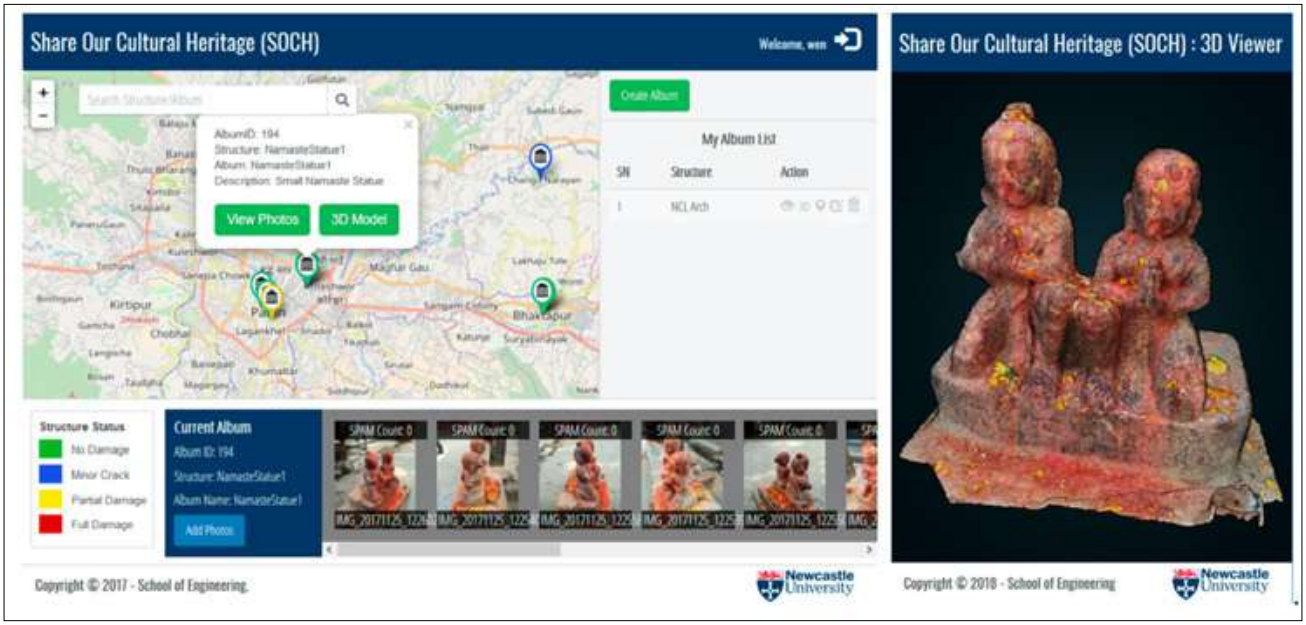
51 Nepal Heritage Documentation Project. Available at https://uni-heidelberg.de/danam

52 Jun Chen and others, "Measuring regional progress towards SDGs by combining geospatial and statistical information", *Acta Geodaetica et Cartographica Sinica*, vol. 48, No. 4 (2019). Available at http://xb.sinomaps.com/EN/10.11947/j.AGCS.2019.20180563

53 Jun Chen and Zhilin Li, "Chinese pilot project tracks progress towards SDGs", *Nature* (7 November 2018). Available at https://www.nature.com/articles/d41586-018-07309-w

54 Yue Qiu and others, "Geospatial disaggregation of population data in supporting SDG assessments: A case study from Deqing County, China", *International Journal of Geo-Information*, vol. 8, No. 8 (2019). Available at https://www.mdpi.com/2220-9964/8/8/356

Figure 6.11 SOCH Platform User Interface, Nepal Heritage Documentation Project



Sources: New Castle University, School of Engineering, "Share Our Cultural Heritage". Available at https://soch.ncl.ac.uk/dashboard and the Heidelberg Academy of Sciences and Humanities, "Nepal Heritage Documentation Project (NHDP). Available at https://www.hadw-bw.de/en/research/research-center/nepal-heritage-documentation-project-nhdp
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Taking a data-driven and evidence-based approach within geospatial frameworks, the team acquired and processed 385 statistical datasets, 66 thematic datasets, and 45 geospatial datasets, including time series remote-sensing data over the past 30 years.[55] The population was disaggregated at a 30-meter spatial resolution to facilitate integrated analysis of statistical and geographic data. In total, the research team measured 102 SDG indicators, which were analysed at three hierarchical levels. First, each indicator was compared against international and national references; second, the indicators were grouped and analysed under each primary SDG; and last, a cluster analysis was conducted to assess economic, social, and environmental circumstances.[56]

Ultimately, the research team concluded that Deqing county had not only made significant economic and social advances, but also maintained a good ecological environment over the past five years.[57] The result produced by the team was able to provide guidance to the local government, effectively building the policy foundation for Deqing's 2020-2022 action plan. In this 3-year window, these plans aim to improve sewage treatment systems, optimize water consumption, increase school bus stations for better allocation of education resources, reconstruct key roads, and rehabilitate forests.[58]

d. The Russian Federation: Space education value chain

In the Russian Federation, space-related education begins in primary school and becomes a lifelong experience for many. For example, special thematic summer camps are organized for school children. For the middle school students, Roscosmos organizes space systems and Remote Sensing-related classes and contests in partnership with the National Technological Initiative. The contest winners then get preferences when applying to partner universities. Roscosmos also fully sponsors an increasing amount of successful high school graduates to enter some of the best technical universities in the country. The young specialists are guaranteed to be employed by the space agency or one of its subordinate organizations after they obtain a degree. Once they join the ranks,

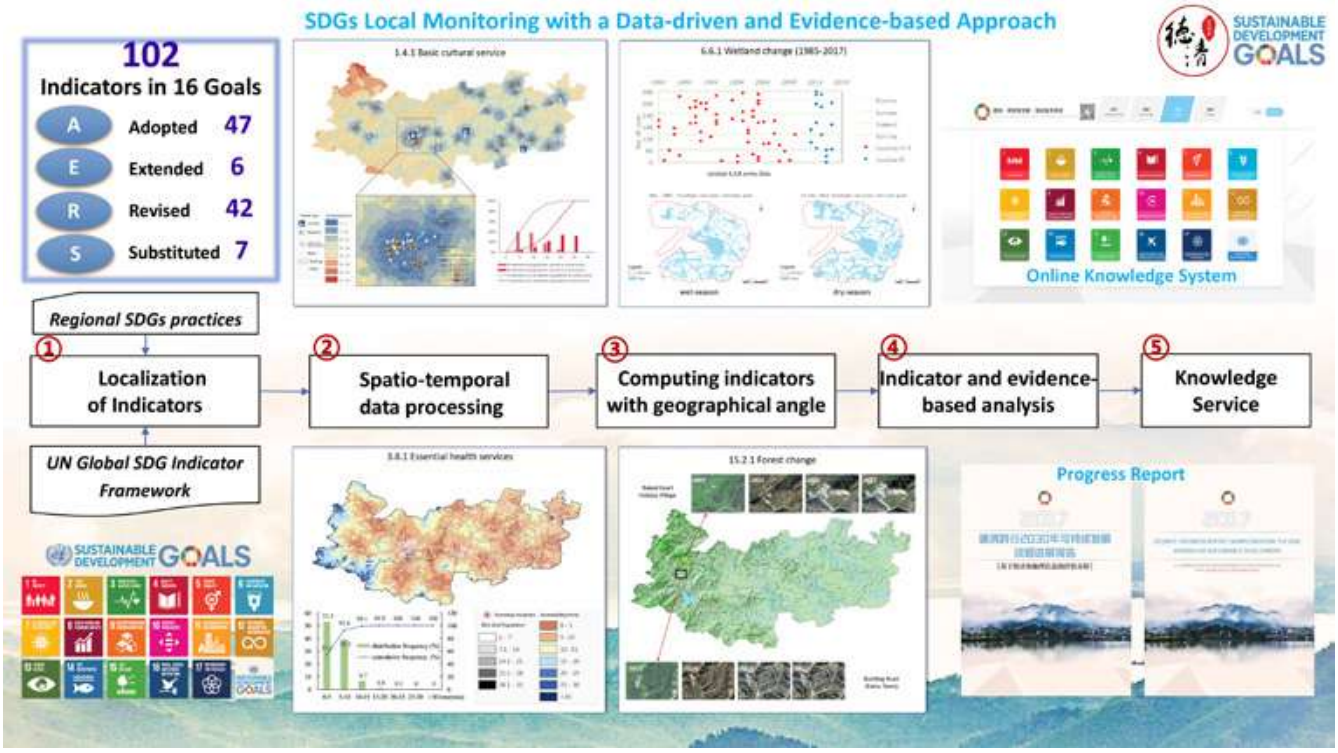
[55] United Nations Sustainable Development Goals Partnership Platform, "SDGs Local Monitoring – China's pilot practice". Available at https://sustainabledevelopment.un.org/partnership/?p=29982

[56] Ibid.

[57] Ibid.

[58] Hao Chen and others, "From SDGs monitoring to decision making – Deqing's three year action plan", UN GGIM Workshop on Data Ecosystem for Sustainable Development, (Deqing, China, 21 October 2019). Available at https://ggim.un.org/meetings/2019/Deqing/documents/2-2%20191021%20From%20SDGs%20Monitoring%20to%20Decision%20Making.pdf

Figure 6.12 Breakdown of the research process in Deqing



Source: United Nations, Sustainable Development Goals Partnerships Platform, "SDGs Local Monitoring – China's Pilot Practice". Available at https://sustainabledevelopment.un.org/partnership/?p=29982
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

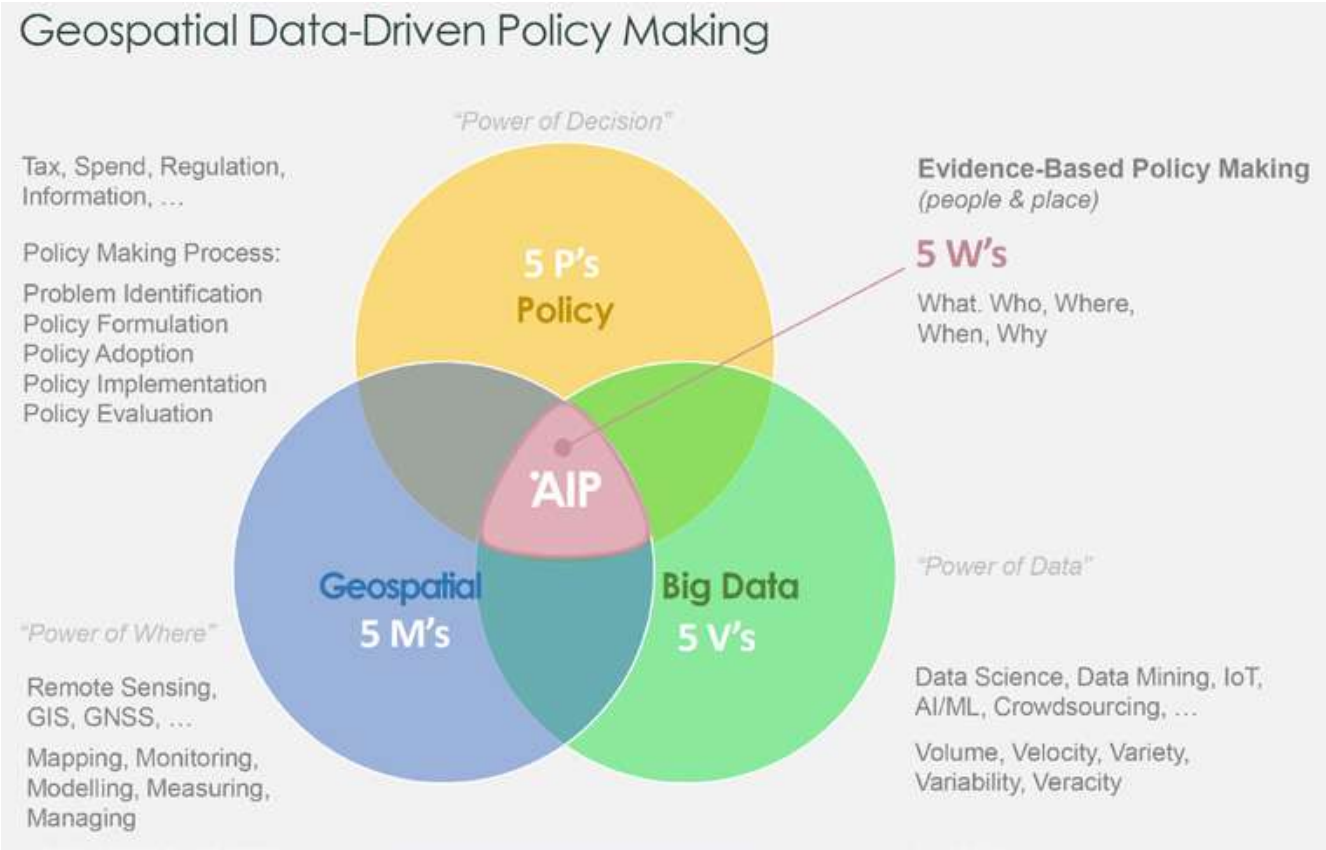
young professionals get involved in seminars, trainings and industry competitions, apart from undertaking their daily duties. The ultimate purpose of such investment across the education value chain is to raise effectiveness and efficiency of production through genuine involvement and incentives. For example, "NPO Energomash" engineers receive bonuses for proposing and planning successful initiatives aimed at quality improvement, production optimization and better labor practices. Senior and managerial staff collaborate and share best practices through various national interagency conferences.

e. Thailand: Actionable Intelligence Policy (AIP)

Thailand's Geo-Informatics and Space Technology Development Agency (GISTDA) partnered with the Nan Provincial Operations Committee to design and develop the Actionable Intelligence Policy (AIP) Platform, that supports evidence-based and data-driven (especially spatial data) policymaking. Corresponding to the urge of Thailand's National Strategy (2018-2030) for geospatial database integration, this platform combines the strengths of satellite data analysis, big geospatial data, crowd sourcing, and Internet of Things (IoT), with new technologies such as artificial intelligence (AI) and machine learning's ability to search and extract insights from target areas and populations. In practice, the AIP platform can provide useful features including, but not limited to, data dashboards, data visualization, and holistic executive support system. An all-in-one tool, the AIP platform is designed with the entire policymaking process in mind, providing support at different stages, from problem identification and characterization, indicator measurement, building cooperation among stakeholders, policy impact simulation, to designing alternative policies.

Currently, the AIP platform is undergoing two trial operations: one in the Eastern Economic Corridor and the other in the Nan province. The AIP had been designed for the Eastern Economic Corridor areas that will aid in decision-making and establishing policies or measures that will balance the development of the Special Economic Corridor in the Eastern region, both in terms of economic, social and environment sustainability for the future. The Nan province, in the North of Thailand, experiences problems of multi-dimensional development, especially within the areas

Figure 6.13 Thailand's geospatial data-driven policy



Source: GISTDA

of forest resources restoration, poverty, and lack of arable land. GISTDA has helped in solving problems by designing the AIP for forestry restoration, so that people can live sustainability with the forest.

Conclusion

These examples highlight the processes already underway within the region toward social development actions, spanning a number of sectors. These include, but are not limited to: social development for urban planning, contamination and pollutants, education and monitoring tools and most recently the COVID-19 pandemic. Many countries within the region demonstrated their capacity through the rapid implementation of geospatial tools and platforms to aid decision makers, Governments and the general public with data driven information. Despite good progress in several countries within the region, there are many challenges that remain to be addressed. These include data integration, rapid data collection, links between policy implementation and action, and data privacy.

This wide range of examples, spanning a variety of practices, demonstrates that the first phase of implementation, of the Plan of Action, is on track to address many sub-themes.

Chapter 7.

Space for socioeconomic development - Highlights for energy

Energy plays an essential role in sustainable development for both its indispensability in daily life and its economic empowering potential. Recognizing this, the 2030 Agenda for Sustainable Development includes the dedicated Sustainable Development Goal (SDG) 7 which ensures access to affordable, reliable, sustainable and modern energy for all. With over 200 million people lacking access to electricity, the Asia-Pacific region needs a shift in the ways that we source, consume and distribute our energy resources in order to achieve SDG 7.[1] The Asia-Pacific Plan of Action on Space Applications for Sustainable Development (2018–2030) (Plan of Action) proposes actions concentrated on the effective use of space-derived data and geographic information systems for identification and mapping of the renewable energy potential, such as hydropower and geothermal, solar and wind energy. Most countries in the region have established targets to improve energy efficiency and increase the share of renewable

[1] *Electricity Connectivity Roadmap for Asia and the Pacific: Strategies toward interconnecting the region's grids* (United Nations publication, Sales No. E.20.II.F.9).

energy.[2] Additionally, policies and programmes have demonstrated significant progress in improving access to electricity; in 2017, the electrification rate for the total population in the Asia-Pacific region reached 94.8 per cent, up from 87.2 per cent in 2010.[3]

According to the Asia-Pacific SDG Progress Report 2020,[4] most of the 2030 targets for SDG 7 are within reach, but require continued accelerated efforts, particularly in the area of energy efficiency and in the share of renewable energy in total energy consumption. For example, steady improvement is noticeable regarding access to electricity across the region, particularly in rural areas. If this trend continues, the Asia-Pacific region will be able to achieve the target of universal access to energy by 2030.[5] The region's rapidly expanding overall energy needs offer a range of challenges and opportunities in improving energy production, aligning policy and creating the necessary conditions to achieve the Goal 7 targets. Space applications offer unprecedented opportunities to collect, manage and visualize data required to make and track progress towards the achievement affordable and clean energy for all. This section provides an overview of the regional status in the priority theme of energy, which highlights country practices and experiences with a focus on renewable energy and open-access information.

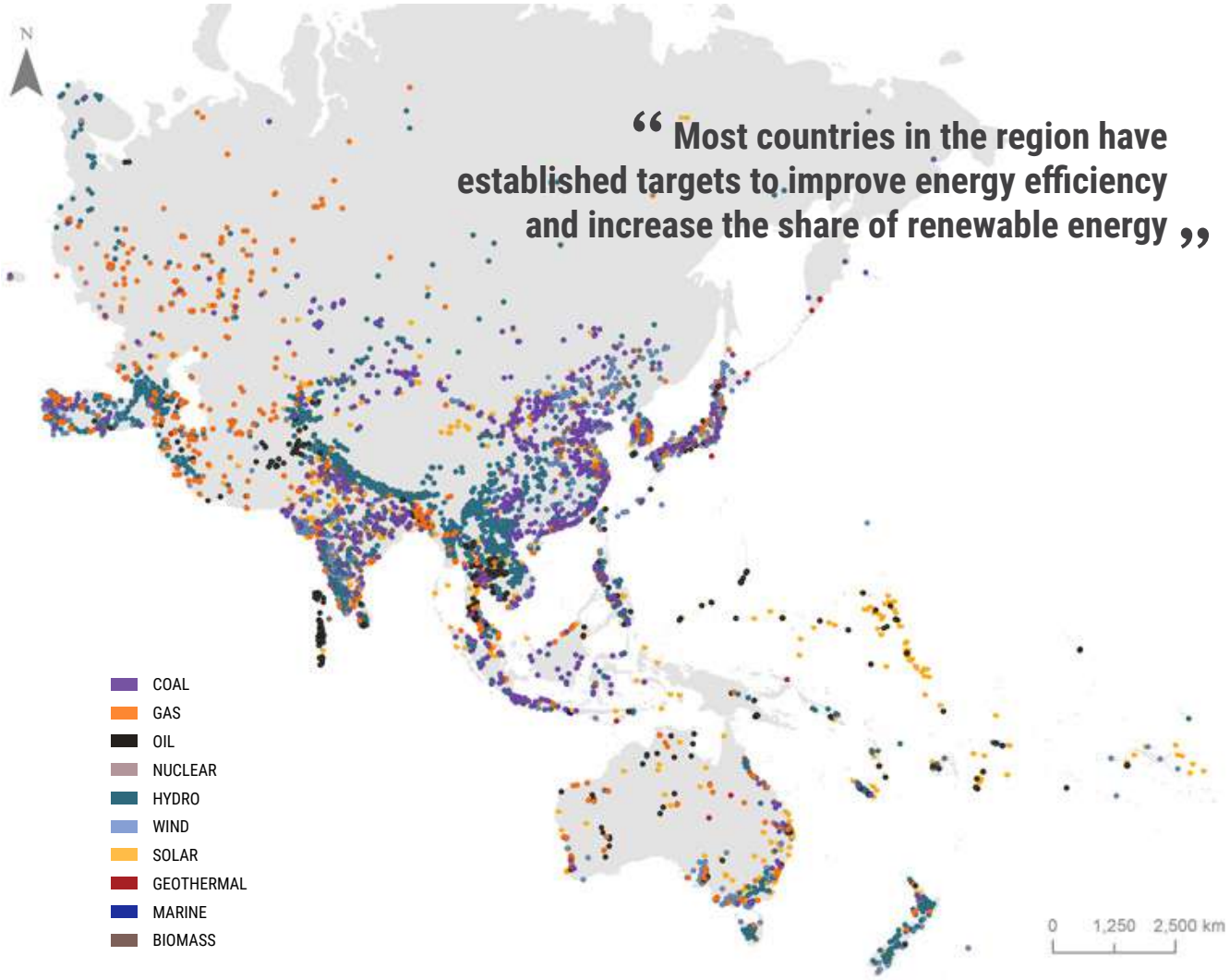
[2] *Asia-Pacific Progress in Sustainable Energy: A Global Tracking Framework 2017 Regional Assessment Report* (United Nations publication, Sales No. E.18.II.F.8). Available at https://trackingsdg7.esmap.org/data/files/download-documents/asia-pacific_regional_gtf_2017_report.pdf

[3] United Nations Conference Centre, Committee on Energy, Second Session, 9 October 2019 to 11 October 2019, Bangkok. See ESCAP/CE/2019/1.

[4] https://www.unescap.org/publications/asia-and-pacific-sdg-progress-report-2020

[5] *Asia and the Pacific SDG Progress Report 2020* (United Nations publication, Sales No. E.20.II.F.10).

Major energy power plans in the Asia-Pacific region, 2019



"Most countries in the region have established targets to improve energy efficiency and increase the share of renewable energy"

Source: ESCAP (2020), Asia-Pacific Energy Portal. Available at asiapacificenergy.org. Accessed 7 October 2020.
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1. Renewable energy infrastructure site appraisal

Due to its advantage in flexible data management and spatiotemporal format, geospatial information is proving to be a useful tool for renewable energy planning and site appraisal. To determine the geographic areas with high technical or economic potential in renewable energy resources, it is necessary to integrate and analyse geographic and topographic factors, such as altitude, climate, and terrain conditions.[6] With the assistance of mapping tools such as GIS, the integration of data is made possible through combining and analysing data layers.[7] In this way, geographical information techniques offer viable solutions towards accurate, consistent, and transparent criteria for renewable energy site selection, which are especially useful for decision-making across multiple stakeholders.

a. IRENA Global Atlas for Renewable Energy

The International Renewable Energy Agency (IRENA) coordinates the Global Atlas for Renewable Energy, an online platform that provides information on renewable energy resources worldwide.[8] This initiative combines the expertise of over 50 specialized international research institutions, offering access to more than 2000 renewable energy maps. It includes comprehensive data on solar, wind, bioenergy, geothermal and marine energy.

In addition, IRENA offers two separate services to support the efforts of Member States in renewable energy planning. The first is the Global Atlas zoning service which offers a GIS-based spatial analysis methodology, developed by IRENA, for utility scale and off-grid applications. Through this analysis, key parameters, such as resource quality, transmission grid distance, population density, topography and protected areas are combined to identify highly suitable zones for solar and wind energy development.

The second service is a site appraisal service, which can be used to determine the viability of prospective sites. Using high quality and site specific solar and wind time series data sets, it applies power and financial models developed by IRENA. These results can support project developers and policymakers in identifying, characterizing and screening potential sites for solar and wind energy deployment.

b. Solar site selection using geospatial information: India, Sri Lanka and Philippines

To determine the suitability of a location for generating solar energy, the Indian Space Research Organization (ISRO) uses solar data derived from measurements on-board the geostationary satellite Kalpana. This is used in conjunction with global horizontal, direct normal and diffuse horizontal irradiance along with capacity utilization factors, these are available at an hourly temporal resolution. By identifying the solar resource described above and temperature of specified locations, ISRO is able to map the richness and potential of solar energy generation across India. In addition, the ISRO employs the Digital Elevation model to find suitable slope for energy extraction, which is a key parameter for installing solar power plants.

The resulting integrated information, on monthly and yearly potential solar energy, at any given location, is available through a web-based GIS interface. Users can access the data by providing a location in the form of geographical coordinates or clicking on the map. Making full use of geospatial information, the interface also provides multi-parameter criteria on factors relevant to site selection, such as slope, distance to existing power grid lines, distance to roads, and land-use (Figure 7.1).[9]

Similarly, Sri Lanka and the Philippines leverage geospatial information and technologies for their own site suitability assessment. To explore its rich wind energy resources that are concentrated in the north western coastal area and central highlands, Sri

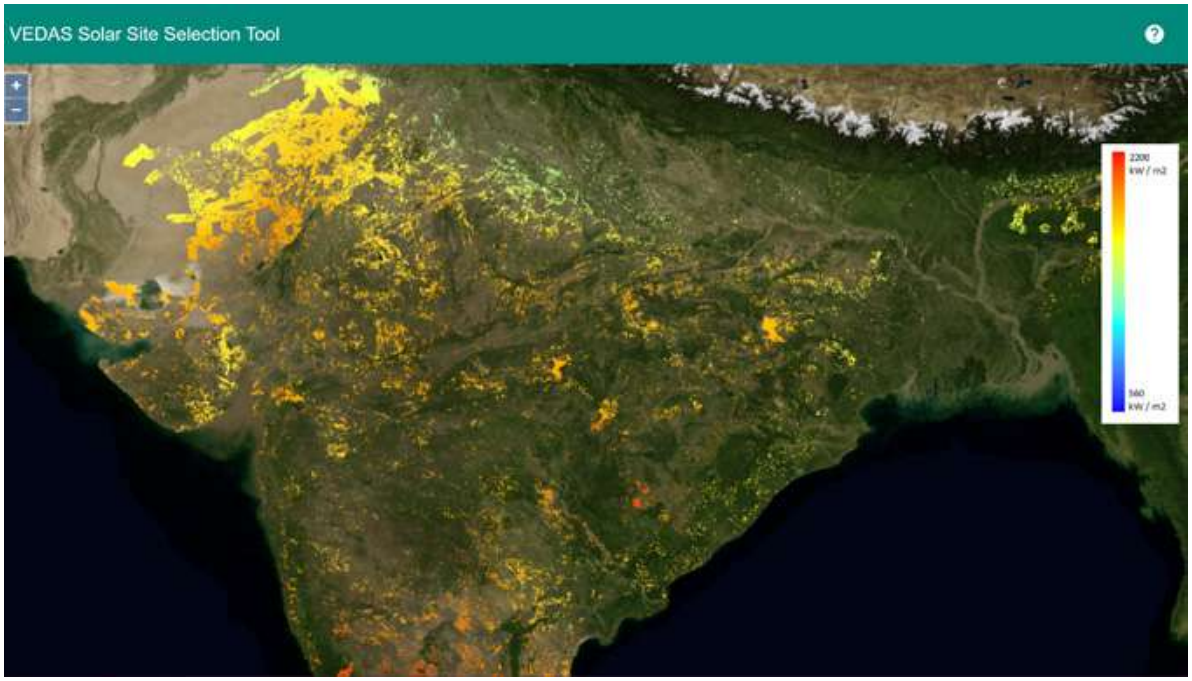
[6] Qianna Wang and others, "A GIS-based approach in support of spatial planning for renewable energy: A case study of Fujushima, Japan", *Sustainability*, vol. 6 (2014). Available at https://www.mdpi.com/2071-1050/6/4/2087/pdf

[7] esri, "GIS best practices: GIS for renewable energy". Available at https://www.esri.com/library/bestpractices/renewable-energy.pdf

[8] International Renewable Energy Agency (IRENA). Available at https://irena.masdar.ac.ae/

[9] Visualisation of Earth Observation Data and Archival System, Space Applications Centre, ISRO. Available at https://vedas.sac.gov.in/vcms/en/home.html

Figure 7.1 The Solar Site Selection Tool Portal based on multi-parameter criteria



Source: Vedas Solar Site Selection Tool. Available at https://vedas.sac.gov.in/s3t/
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Lanka partnered with the National Renewable Energy Laboratory in developing its Wind Resource Map in 2003.[10] Using the resulting data, Sri Lanka reached 131 MW generation capacity by the end of 2017.[11] Similarly, the Philippines uses LiDAR technology to produce refined and localized assessment for wind, solar, hydropower, and biomass resources. The product maps are turned over to the Department of Energy to identify both potential theoretical capacity and potential sites.

2. Open-access information platforms

The emergence of open-access information platforms add value to geospatial information on renewable energy by providing structured access towards multiple sources and types of geospatial data, in combination with other practical considerations, such as policy and investment landscape. A well-organized open-access platform provides the following key benefits for energy planning. Firstly, in order to reduce unnecessary efforts spent on duplicate projects, open-access data and analysis increases awareness towards existing results and resources, efficiently connecting knowledge and parties in need of information. Secondly, open-access platforms maintained by reputable entities supply data validation, a function vitally important for parties incapable of obtaining or verifying energy information on their own. The reliability of open-access information platforms can contribute towards closing the technical gaps. Lastly, open-access information can render the renewable energy industry more transparent to all involved stakeholders, from the public, to operators, to policymakers. This transparency could lead to greater interest in and acceptance towards renewable energy implementation.

a. The Global Electrification Platform

Electricity is fundamental to socioeconomic development. Data collection and analysis is a vital tool for the documentation and measurement of progress towards the achievement of the SDGs and to support government decision-making. One of the main challenges that remains is the ensuring of universal access to electricity. While significant progress was recorded in global electrification, energy access gaps still remain. Nonetheless, remote sensing technologies and improved access to GIS provide large amounts of location-specific, socio-economic and infrastructure data to support the documentation and analysis process.

[10] Asian Development Bank, "Sri Lanka: Energy sector assessment, strategy, and road map", December 2019. Available at https://www.adb.org/sites/default/files/institutional-document/547381/sri-lanka-energy-assessment-strategy-road-map.pdf

[11] Ibid.

The World Bank, in collaboration with the division of Energy Systems Analysis at KTH Royal Institute of Technology, Development Seed, the World Resources Institute, Cambridge University, Google and the ABB Group, has developed the Global Electrification Platform (GEP),[12] an open-source tool providing data and analysis for integrating and bringing down costs of electrification in rural areas (Figure 7.2). This interactive, online platform provides an overview of electrification investment scenarios for selected countries, which present pathways for achieving universal electricity access, subdivided into an intermediate strategy for 2025 and full electrification by 2030. The tool offers three different levels of detail, targeting the specific needs of four primary target audiences: high level decision makers, policy and investment analysts, data producers and ICT developers, and global development organizations. To ensure interoperability between all users, joint data standards and processing protocols were developed and are continuously improved and updated.

The tool presents a total of 216 different scenarios to meet the access goals, which can be explored by the adjustment of combinations and parameters. Additional information layers, for example wind potential, electricity networks, location of health facilities, can be overlaid to help illustrate and contextualize information for a selected country.

[12] Global Electrification Platform. Available at https://electrifynow.energydata.info

b. Monitoring rural electrification from space

Universal access to electricity is an essential step towards sustainable development, particularly for remote, rural areas, which are often still underserved. The monitoring of rural electrification is a valuable tool to quantify the impact and sustainability of ongoing global electrification efforts. Today, geospatial data, in combination with improved data processing technologies, offers unprecedented possibilities to monitor electrification from space. In 2011, the University of Michigan, in collaboration with the US National Oceanic and Atmospheric Administration and the World Bank Group, started analysing the correlation between satellite-derived night lights data and electrification on the ground to improve the monitoring of electricity supply.[13]

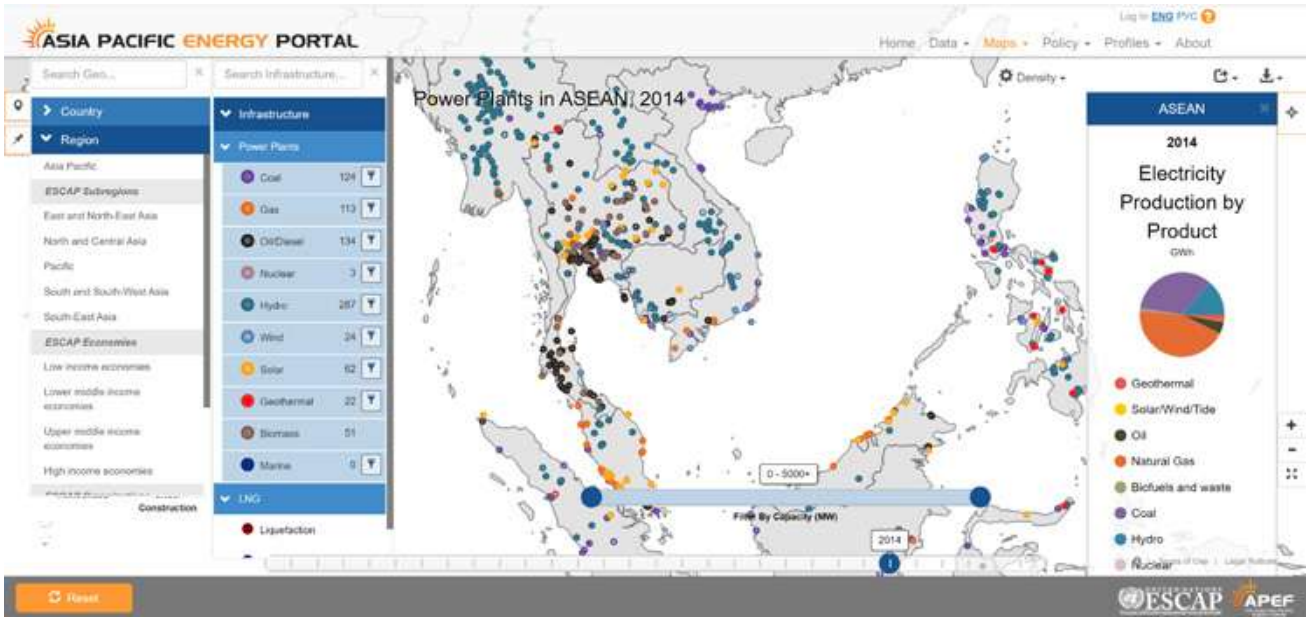
Initially, the project focused on analysing the status of Viet Nam, which already has near-universal electrification. The project then expanded its geographic scope to cover India, which has a high density of rural population, as well as a large rural electrification programme. Using night-time satellite imagery for a period of 20 years, the project applied GIS technology to process and analyse a dataset of approximately five billion observations and verified

[13] Kwawu Mensan Gaba, "Monitoring Rural Electrification from Space", World Bank Group. Available at https://olc.worldbank.org/system/files/WBG_BD_CS_RuralElectric_1.pdf

Figure 7.2 Global Electrification Platform

Source: Global Electrification Platform. Available at https://electrifynow.energydata.info
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Figure 7.3 Asia-Pacific Energy Portal



Source: Asia Pacific Energy Portal. Available at https://asiapacificenergy.org/
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

improvements of electrical supply by comparing information from official electrification programme records. In addition to electricity access, the available data density also allowed analysis of power supply stability and developed visualization aids were made accessible through an online toolkit.

The online toolkit provides power companies, regulatory agencies and other stakeholders with geo-referenced satellite imagery and maps that can support visualization and analysis of patterns and trends in electricity supply.[14] Through this dashboard, technical partners can access light output at village, district, region or state levels across India. This initiative demonstrated that night-time satellite imagery can serve as a reliable tool to analyse the use of electricity, particularly in rural regions with limited infrastructure and small numbers of users.

c. Asia-Pacific Energy Portal

Following the 2013 Asian and Pacific Energy Forum (APEF), and in response to the request of Member States for improved dissemination and exchange of information to increase the coherence and availability of energy statistics and policy-related information, the Asia Pacific Energy Portal was developed by the ESCAP Secretariat with the support of the Russian Federation.[15]

The portal is a comprehensive interactive data and policy information tool to support research, analysis, and informed decision-making for the energy sector in the Asia-Pacific region (Figure 7.3). It provides open access to data and policy information on energy and sustainable development and combines information from more than 200 datasets from global institutions including UN Data, the International Energy Agency, the World Bank, UN Comtrade, IRENA, and Bloomberg. The platform's energy resource and infrastructure maps include information on over 7,000 power plants across the region.

Using georeferenced data, the tool provides access to an extensive set of energy statistics, enabling identification of trends and rapid analysis of data, visualizing patterns, relationships and impacts that drive energy systems development. Custom data analysis for specific indicators and countries can be used to link information on energy infrastructure and resource use with broader development issues and help with identifying potential regional efficiencies in energy production and distribution.

[14] Twenty Years of India Lights. Available at http://india.nightlights.io

[15] Asia Pacific Energy Portal, "Energy Information for the Asia-Pacific Region". Available at https://asiapacificenergy.org

In addition, the website serves as a repository for over 3,000 policy documents that have been collected from hundreds of official websites. Together, these full-text policies, and interactive infrastructure maps serve as a powerful tool to support informed decision-making among the Asia-Pacific region's energy policymakers, as well as policy tracking, research and analysis for regional and global initiatives. Policy timelines can be plotted on timelines according to themes, such as energy access, efficiency, and renewables.

d. The Russian Federation: Digital Earth Project and Sputnik GIS product line for energy

In 2017, the Russian Federation, through the Russian Space Agency ROSCOSMOS implemented the Digital Earth concept of new space remote sensed technology, a new paradigm for the Russian Federation space industry and national space remote sensing.[16] Through the Digital Earth project, ROSCOSMOS simulates development of the economy of the Russian Federation in accordance with the new "digital" trends.[17] The technical infrastructure of the Russian Digital Earth project is a synthesis of several state-of-the-art components including a remote sensing satellite constellation, the Russian Federation's own GNSS system GLONASS, a common geographically distributed information system of remote sensing, and the International Global Aerospace System (IGMAS).[18] Together these technologies form the infrastructural backbone for this ambitious project, allowing for repeatedly updated, seamless mosaics of satellite images of Earth with near 1-meter resolution.[19] To implement the Digital Earth project, RSS has set up a single geographically distributed information system of remote sensing of Earth consisting of 13 centres across the Russian Federation.

The synergy between Digital Earth and Digital Economy has facilitated a number of initiatives across public and private sectors exemplified by the following:

Sputnik GIS[20]

A product of the involvement of private businesses in Digital Earth's research and development, the Sputnik GIS is a multipurpose spatial-data visualization tool by Geoscan Group. Sputnik GIS is based on the Digital Earth paradigm and has gradually expanded its functionality since its initiation in 2009. As of 2020, Geoscan has implemented several useful features, such as change detection, volume calculation, section generation, contour generation, slope maps, creation and visualization of the normalized difference vegetation index (NDVI), thermal maps and power line analysis. The current iteration of Sputnik GIS product line has been adopted by various industries, including energy, urban planning, and agriculture.

Roscosmos Geoportal[21]

The Roscosmos Geoportal is an innovative hub of global satellite imagery that is updated on a daily basis. Up to 50 scenes collected from Russian satellites, Resurs-P, Kanopus-V, and Meteor-M are added to the geoportal every day.[22] The unique characteristic of this geoportal is that it realizes the combination of the means of viewing satellite images and the means of Earth remote sensing data search. The customers can not only make requests for archived data, but also order new surveys with specified parameters.

Conclusion

These examples show the variety of benefits that space applications, geospatial information and data can contribute to the field of energy. They also demonstrate the importance of geospatial information in working towards the SDGs, especially under SDG 7. These examples are especially aligned with the Plan of Action and highlight the use of geospatial information through a number of actions, such as research and mapping renewable energy potential and determining energy demand and consumption. This shows that countries around the region are on track toward the first phase of implementation, under the Plan of Action and, through innovative, technological approaches more progress can be made to ensure that goals and standards are met.

[16] President of Russia, Presidential Executive Office, "Meeting on developing the space sector", 22 May 2017. Available at http://en.kremlin.ru/events/president/news/54539http://en.kremlin.ru/events/president/ news/54539.

[17] Yuri M. Baturin and others, "Digital Earth in Russia" in *Manual of Digital Earth* (SpringerOpen, November 2019). Available at https://link.springer.com/content/pdf/10.1007%2F978-981-32-9915-3_23.pdf

[18] Ibid.

[19] International Society for Digital Earth, "Digital Earth implement in Russia". Available at http://www.digitalearth-isde.org/news/810

[20] GEOSCAN, "Sputnik GIS". Available at https://www.geoscan.aero/en/software/sputnik/gis

[21] Roscosmos Geoportal, Satellite images service. Available at https://gptl.ru/

[22] Roscosmos Geoportal, Satellite images service. "About the project". Available at https://gptl.ru/about

Chapter 8.

Space for socioeconomic development - Highlights for climate change

Climate change is projected to slow development and impact a wide scope of factors ranging from economic growth, food security, and poverty reduction, particularly in urban, coastal, and agricultural areas.[1] Recognizing the need for an effective and progressive response to the urgent threat of climate change, the 2015 Paris Agreement aims to strengthen global response, by all countries agreeing to limit the global

[1] United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), "Population dynamics, vulnerable groups and resilience to climate change and disasters", Midterm Review of the Asian and Pacific Ministerial Declaration on Population and Development (ESCAP/APPC/2018/4). Available at https://www.unescap.org/sites/default/files/ESCAP-APPC-2018-4%20%28EN%29.pdf

temperature rise well below 2°C.[2] Indeed, the Asia-Pacific region needs to take quick action on climate change mitigation and adaptation, in order to achieve the SDGs and ensure sustainable livelihoods for all.

The Asia-Pacific region faces the most risk, in the world, to the impacts of climate change, housing five of the top ten countries most vulnerable to climate change.[3] The geographic composition of the region, which includes extended coastlines and low-lying territories, presents a series of vulnerabilities to rising sea-levels and extreme weather events that are exacerbated by climate change.[4] It has been predicted that with a 2-meter rise of sea level by 2100, a population of approximately 187 million people, most of whom live in Asia, would be displaced.[5] Climate change also affects and impacts social development and human health. Directly, extreme climate events, such as heatwaves, floods, and storms can result in deaths, injuries, and disabilities. Indirectly, climate change can create favourable environments for climate-sensitive infectious diseases to spread, worsening morbidity and mortality.[6]

In addition, heatwaves and droughts alike can undermine agricultural productivity and food security by shifting the patterns of rainfall and temperature. In Asia and the Pacific, millions who rely on natural resources for livelihoods are set to bear the brunt of the impacts of climate change.[7] To further complicate the matter, many nations in the Asia-Pacific region face the challenge of simultaneously coping with the effects of climate change and raising the living standards of their citizens.[8] Conflicting development interests could lead to difficult decision-making. For instance, as the region continues to rapidly urbanize, the adverse impacts of climate change could exacerbate the vulnerable situations of the urban poor, who tend to have limited access to housing, basic services, and social protection.[9]

The recent COVID-19 pandemic could potentially introduce even more volatility to the climate outlook for the Asia-Pacific region. While economic slowdown and mobility restrictions result in environmental relief, there is a potential rebound, or even increase, in environmental externalities during the post-pandemic rebuilding process. In the "Socio-Economic Response to COVID-19: ESCAP framework",[10] ESCAP calls for due attention toward identifying the challenges and opportunities for environmental sustainability resulting from COVID-19, in order to build a stronger policy foundation.

The development and application of geospatial information presents valuable opportunities for mitigating the above impacts. The Asia-Pacific Plan of Action on Space Applications for Sustainable Development (2018–2030) (Plan of Action) proposed a series of actions that leverage the benefits of Earth observation, remote sensing, and global navigation satellite systems (GNSS).[11] These space-enabled technologies have either proven to be effective or have demonstrated promising potential in fields that include, but are not limited to, climate and weather modelling, vulnerability mapping, greenhouse gas monitoring, carbon and environmental monitoring and capacity-building.[12] The following examples illustrate and provide an overview of the progress made by countries in recent years towards SDG 13, Climate Action.

2 For more information, See
United Nations, "Paris Agreement", 2015. Available at https://unfccc.int/sites/default/files/english_paris_agreement.pdf and
United Nations, Sustainable Development Goals, "Goal 13: Take urgent action to combat climate change and its impacts". Available at https://www.un.org/sustainabledevelopment/climate-change/ and
Economic and Social Survey of Asia and the Pacific 2017: Governance and Fiscal Management (United Nations publication, Sales No. E.17.II.F.8). Available at https://www.unescap.org/sites/default/files/publications/Survey%202017-Final.pdf and
Economic and Social Survey of Asia and the Pacific 2020: Towards Sustainable Economies (United Nations publication, Sales No. E.20.II.F.16). Available at https://www.unescap.org/sites/default/files/publications/Economic%20and%20Social%20Survey%20of%20Asia%20and%20the%20Pacific%202020%20Towards%20sustainable%20economies.pdf#page=27

3 Ibid.

4 Kazuyuki Uji, "The health impacts of climate change in Asia-Pacific", United Nations Development Programme, Asia-Pacific Human Development Report Background Paper Series 2012/16. Available at https://www.undp.org/content/dam/rbap/docs/Research%20&%20Publications/human_development/aphdr-2012-tbp/RBAP-HDR-2012-APHDR-TBP-16.pdf

5 United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), "Population dynamics, vulnerable groups and resilience to climate change and disasters", Midterm Review of the Asian and Pacific Ministerial Declaration on Population and Development (ESCAP/APPC/2018/4). Available athttps://www.unescap.org/sites/default/files/ESCAP-APPC-2018-4%20%28EN%29.pdf

6 Ibid.

7 United Nations Development Programme (UNDP) Asia and the Pacific, "Climate change in Asia and the Pacific. What's at stake?" 28 November 2019. Available at https://www.asia-pacific.undp.org/content/rbap/en/home/presscenter/articles/2019/climate-change-in-asia-and-the-pacific.html

8 Ibid.

9 United Nations Development Programme (UNDP) Asia and the Pacific, "Urbanization and climate change", 18 August 2015. Available at https://www.asia-pacific.undp.org/content/rbap/en/home/library/sustainable-development/urbanization-climate-change-issue-brief-1.html

10 United Nations Economic and Social Commission for Asia and the Pacific, "Socio-Economic Response to COVID-19: ESCAP framework". Available at https://www.unescap.org/sites/default/files/ESCAP%20COVID-19%20Framework%20Paper.pdf

11 United Nations Economic and Social Commission for Asia and the Pacific, "Asia-Pacific Plan of Action on Space Applications for Sustainable Development (2018-2030). Available at https://www.unescap.org/sites/default/files/3rdMC-SASD-Plan-of-Action.pdf

12 Ibid.

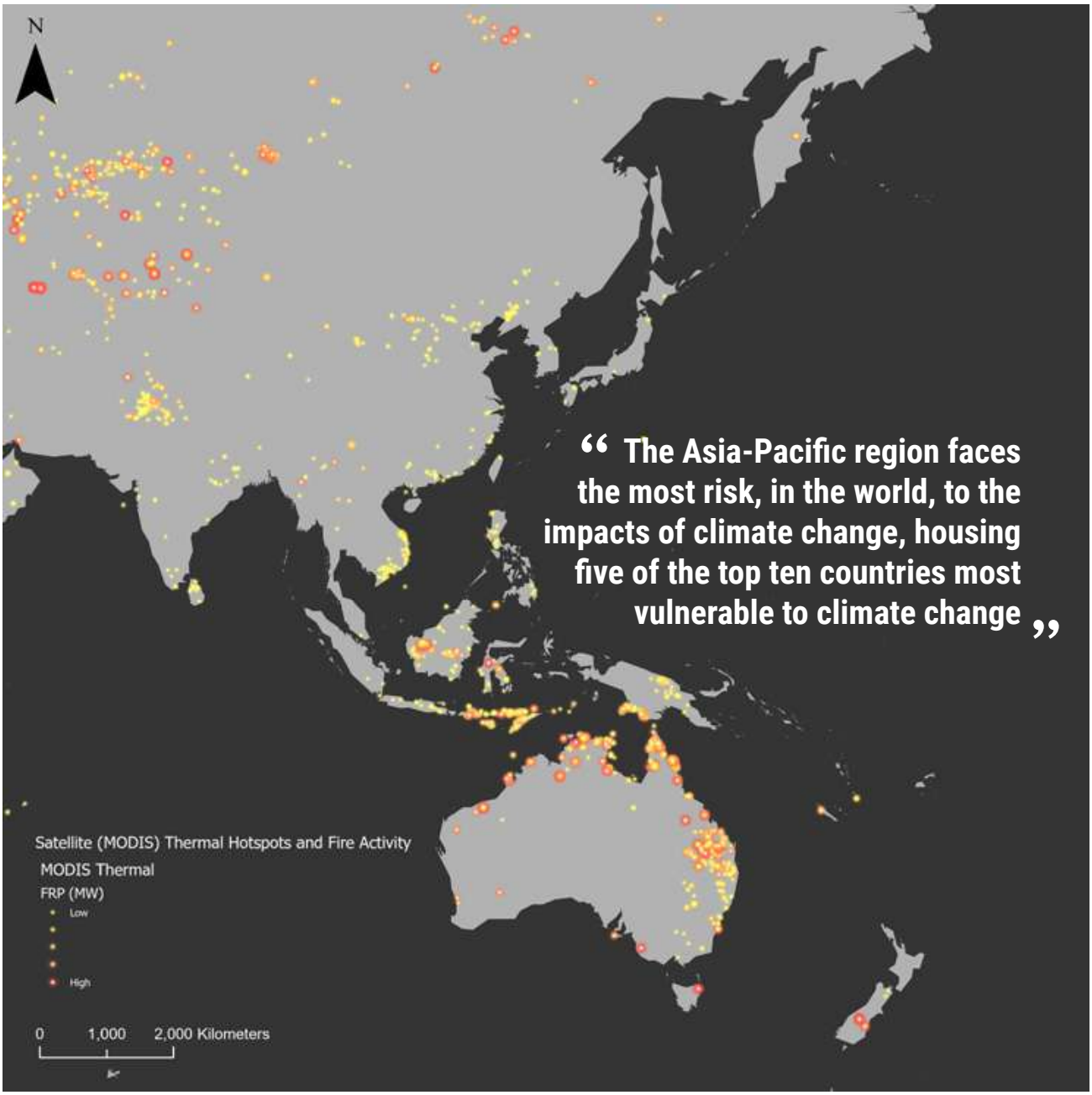
1. Climate modelling and projections

Climate data can be classified as part of the Earth observation (EO) and geospatial data domain, as this data describes a location/region of the Earth through a set of attributes.[13] Today, the volume of climate data worldwide is expanding rapidly and arising in continuous streams from multiple sources, such as in-situ sensor measurements (temperature, precipitation, wind) and remote sensing observations (satellite, aircraft, Unmanned Aerial Vehicle (UAV)).[14] This growth expands the potential

[13] Gregory Giuliani and others, "Spatially enabling the Global Framework for Climate Services: Reviewing geospatial solutions to efficiently share and integrate climate data and information", *Climate Series*, vol. 8 (December 2017). Available at https://www.sciencedirect.com/science/article/pii/S2405880716300772

[14] Ibid.

Example of Thermal Hotspots in the Asia-Pacific Region, for a 48-hour time period in October 2020



> "The Asia-Pacific region faces the most risk, in the world, to the impacts of climate change, housing five of the top ten countries most vulnerable to climate change"

Map developed by ESCAP. Data Source: https://www.arcgis.com/home/item.html?id=b8f4033069f141729ffb298b7418b653
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

of geospatial information to effectively support multiple communities and regions in their climate adaptation and mitigation planning. This can be done by providing the right data, at the right time, and in the right place. Climate change modelling and projection activities leverage this trend and bring interoperability along the entire climate data value chain, facilitating the storing, visualizing, accessing, analysing, and integrating of climate data.[15] Furthermore, with the assistance of techniques, such as Regional Climate Downscaling, climate models can now be tailored to a specific context, to answer customized questions, and to identify local priorities, catering to special needs.[16] Additionally, climate modelling and projections provide an opportunity for integration and collaboration between meteorological and space agencies. Finally, model customization also creates opportunities for local communities to participate, contributing to the reliability of the models as well as a sense of ownership.[17]

a. Philippines: High resolution climate change projections and regional climate simulations for improved climate information

The Philippines, through the Philippine Council for Industry, Energy and Emerging Technology Research and Development (DOST-PCIEERD), has developed national, high resolution (5 km) climate change projections using the Weather Research and Forecasting model for 2040 to 2060. These precipitation and temperature projections fall under two different climate scenarios, high greenhouse gas concentration (RCP 8.5) and intermediate greenhouse gas concentration (RCP 4.5).[18] The high-resolution projections provide added value into climate research and enable more specific analysis and projection maps to help decision makers prioritize and plan more effectively. The Philippine Atmospheric, Geophysical and Astronomical Services Administration (DOST-PAGASA) has also conducted similar national climate projection activities.

b. Malaysia: Big Data Analytics Proof-of-Concepts project (BDA-POC) for climate impact modelling and mapping[19]

The National Hydraulics Research Institute of Malaysia has been using Big Data Analytics (BDA) technology to help stakeholders determine the areas that are at risk of substantial climate change impacts. The project is designed as a Decision Support System for water projections in the contexts of climate change impacts. There are three driving approaches behind this project: the Regional Hydroclimate Model, the Watershed Environmental Hydrology-Hydroclimate Model, and the National Hydraulics Research Institute of Malaysia Hydroclimate Data Analysis Accelerator-Climate Change Knowledge Portal, which is capable of providing visualization of climate-environment data. Government agencies, developers, town planners, risk managers, insurance companies, and water operators obtain climate impact maps from this service to devise strategic plan for mitigation and adaptation for combating climate change.

This BDA technology offers an intelligent platform for decision makers to design long-term climate proofing risk management strategies for a series of issues, such as agriculture, energy, and health. For example, the National Hydraulics Research Institute of Malaysia supplied analysed data and information through the N-HyDAA portal to assist the Sustainable Water Consumption through Water Footprint and Water Risk Management project.

c. Sri Lanka: Estimating the impact of climate change on agriculture

Agriculture is vital to Sri Lanka's rural economy. Given the country's diverse ecological conditions, smallholder farmers, who make up the overwhelming majority of the country's farmers, have long sought ways to build resilience under increased change

[15] Gregory Giuliani and others, "Spatially enabling the Global Framework for Climate Services: Reviewing geospatial solutions to efficiently share and integrate climate data and information", *Climate Series*, vol. 8 (December 2017). Available at https://www.sciencedirect.com/science/article/pii/S2405880716300772

[16] Andrea N. Bassi and others, *Modelling for Sustainable Development: New Decisions for a New Age* (Canada, International Institute for Sustainable Development, 2019). Available at https://iisd.org/sites/default/files/publications/modelling-for-sustainable-development.pdf

[17] Ibid.

[18] A Representative Concentration Pathway (RCP) is a greenhouse gas concentration scenario adopted by the Intergovernmental Panel on Climate Change.

[19] Mohammad Zaki M. Amin and others, "Big data analytics technology for water risk assessment and management", *Tech Monitor* (July-September 2017). Available at http://techmonitor.net/tm/images/6/66/17jul_sep_sf3.pdf

and variability in climate.[20] Led by the Department of Agriculture and with the training provided by the Capacity Building Programme on the Economics of Climate Change Adaptation in Asia, Sri Lanka uses climate change projections to evaluate the impact of climate change on agriculture.[21] The modelling approach used calculates the average changes and spatially aggregates the district-level data, based on the extent of each district.

Estimates on the impact of climate change on crop farmers, in Sri Lanka, is produced using climate projections from these models. Starting with the 2031-2060 projections, the full sample result shows that the impact of climate change on net revenue per acre is negative. On average, the impact of precipitation forecasts in net revenue per acre is positive for irrigated farmers and negative for non-irrigated farmers, but the temperature effect outweighs any gain from precipitation to irrigated farmers. The impact is incremental across the projection years.

Finally, the analysis focuses on the impact of climate change by district. Using the model described above, the impact of changes in temperature and precipitation is estimated based on the Beijing Normal University Earth System Model and farm area by district. Impacts are calculated based on agricultural planted area and can be interpreted as the potential loss in agricultural revenue by 2030. This analysis can be used for climate change adaptation and mitigation planning from the local to national level.

2. Vulnerability and risk mapping

The development and evolution of space applications, such as GIS, digital elevation models (terrain mapping), and GNSS (pinpointing locations) has made accurate vulnerability mapping practically viable. Mapping vulnerabilities to climate change is key to formulating climate-resilient plans.[22] Currently, multiple countries and entities are already using vulnerability "hotspot" maps to identify geographic areas where physical or social impacts are expected to be greatest, and which may therefore require adaptation interventions.[23]

[20] https://climateknowledgeportal.worldbank.org/sites/default/files/2019-06/CSA%20in%20Sri%20Lanka.pdf World Bank; CIAT. 2015. Climate-smart agriculture in Sri Lanka. CSA country profiles for Africa, Asia, and Latin America and the Caribbean series. Washington D.C.: The World Bank Group.

[21] United Nations Development Programme (UNDP) and United States Agency for International Development (USAID), "Economics of Climate Change Adaptation: Understanding the impact of climate change on the agriculture sector and optimal policy response in Sri Lanka". Available at https://www.uncclearn.org/sites/default/files/inventory/ecca-country-report-sri-lanka.pdf

[22] United Nations Development Programme (UNDP), "Mapping Climate Change Vulnerability and Impact Scenarios: A guidebook for sub-national planners", November 2010. Available at https://www.adaptationcommunity.net/?wpfb_dl=58

[23] ArcGIS, Cuyahoga County Planning Commission, Cuyahoga County Climate Change Vulnerability Map. Available at https://www.arcgis.com/apps/webappviewer/index.html?id=7154ce92af264bedbeb4a70c61991e0a

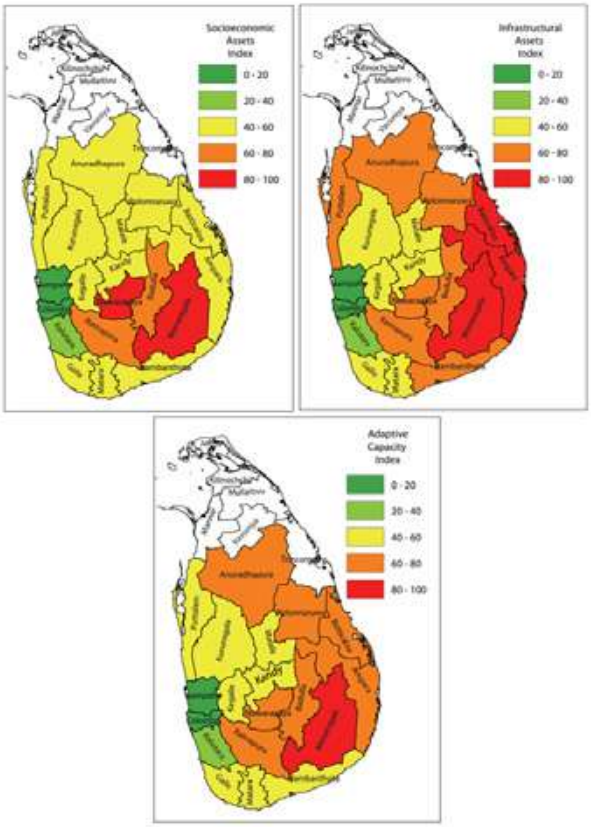
Vulnerability maps synthesize cross-sectoral data, including climate, biophysical, and socioeconomic data, among others. These maps do not only serve as a decision-making tool, but can be part of the standard toolkit for communicating the risks of climate change to the general public.[24] Despite the efficacy of vulnerability mapping as a tool, it is crucial to recognize that it is only one step towards climate resilience. Subsequent decision-making processes involving all relevant stakeholders are required to identify and prioritize appropriate adaption responses for the identified vulnerabilities.[25]

a. Sri Lanka: mapping the impact of climate change on water resources and agriculture

The Government of Sri Lanka partnered with the International Water Management Institute (IWMI) to conduct a study titled, "Impact of Climate Change on Water Resources and Agriculture in Sri Lanka: A Review and Preliminary Vulnerability Mapping." The results significantly influenced Sri Lanka's climate change strategies and policies.[26] The study provided background information and identified research gaps on the impacts of climate change for the agricultural sector and water resources.[27] It used a climate change vulnerability index to identify climate change hotspots in agriculture, providing valuable insights into the shifting precipitation patterns, stress on water resources, and impacts on crops, such as paddy rice, tea, and coconut.[28]

The analysis from the IWMI informed Sri Lanka's Second National Communication to the United Nations Framework Convention on Climate Change (UNFCCC) before the 2010 United Nations Climate Change Conference. The study was then incorporated into the country's National Climate Change Adaptation Strategy for 2011-2016. An ex-post impact assessment of the research confirmed the significant influences on Sri Lanka's national strategies brought about by this study.[29]

Figure 8.1 Components of adaptive capacity index and the composite adaptive capacity index for each district in Sri Lanka



Source: International Water Management Institute (IWMI). Available at: http://www.iwmi.cgiar.org/Publications/IWMI_Research_Reports/PDF/PUB135/RR135.pdf
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

b. South Asia: Mapping multiple climate hazards

Also published by the IWMI, with support from the United Nations University – Institute for Water, Environment and Health and CGIAR Research Program on Climate Change, Agriculture and Food

[24] Alex de Sherbinin and others, "Climate vulnerability mapping: A systemic review and future prospects", Wiley Online Library, 15 July 2019. Available at https://onlinelibrary.wiley.com/doi/full/10.1002/wcc.600

[25] United Nations Development Programme (UNDP), "Mapping Climate Change Vulnerability and Impact Scenarios: A guidebook for sub-national planners", November 2010. Available at https://www.adaptationcommunity.net/?wpfb_dl=58

[26] Nishadi Eriyagama and others, "Impacts of climate change on water resources and agriculture in Sri Lanka: A review and preliminary vulnerability mapping", International Water Management Institute (IWMI) Research Report, No. 135 (Colombo, 2010). Available at http://www.iwmi.cgiar.org/Publications/IWMI_Research_Reports/PDF/PUB135/RR135.pdf

[27] Climate Change, Agriculture and Food Security (CCAFS), "IWMI's vulnerability mapping shapes Sri Lanka's National Climate Change Adaptation Strategy", 2011. Available at https://ccafs.cgiar.org/research/results/iwmi%E2%80%99s-vulnerability-mapping-shapes-sri-lanka%E2%80%99s-national-climate-change-adaptation#.Xs2lmRNKggA

[28] Ibid.

[29] V. Ratna Reddy, "Ex-post impact assessment of the study: 'Impact of Climate change on water resources and agriculture in Sri Lanka', Livelihoods and Natural Resource Management Institute, Hyderabad, April 2015. https://cgspace.cgiar.org/bitstream/handle/10568/67169/IWMI%20CCAFS%20Review.pdf?sequence=1

Security, studies were conducted to map out the potential climate hazards in the South Asian region, with the datasets provided by multiple institutions, including the NASA. By making use of the satellite data and other data sources, the report and toolbox are available to provide new predictions once new or superior datasets are available.

The assessment provided in the report allows South Asian countries to evaluate their policies and resources allocated to different regions in order to to adapt to changes in climate and prevent natural disasters that leads to economic losses and casualties. An overall vulnerability adaptive capacity was analysed to better highlight those regions that require immediate attention. As a uniform assessment methodology is adopted, countries are able to exchange their preparation for a particular hazard of similar exposures.[30]

3. Greenhouse gas, carbon and environmental monitoring

Monitoring pollution and greenhouse gas (GHG) emissions from space began in 2009, when Japan launched the world's first satellite dedicated to greenhouse gas monitoring, the Greenhouse Gases Observing Satellite (GOSAT). It measures carbon dioxide (CO_2) and methane densities from 56,000 locations around the world. In 2018, the JAXA launched GOSAT-2 to collect and generate even more precise data.[31] Additionally, several remote sensing techniques can be used to measure atmospheric concentration of greenhouse gases.[32] For example, the Thailand Greenhouse Gas Management Organization (TGO) is monitoring greenhouse gas emissions at the provincial level due to land use changes based on satellite data and greenhouse gas surveying. The GHG concentrations are regularly updated and displayed through the service channels of the TGO.[33]

a. China: TanSat mission to promote global carbon monitoring

The TanSat mission is the first Chinese mini-satellite dedicated to the detection and monitoring of carbon dioxide (CO_2). In 2016, the satellite was launched into space, making China the third country after Japan and the United States to monitor greenhouse

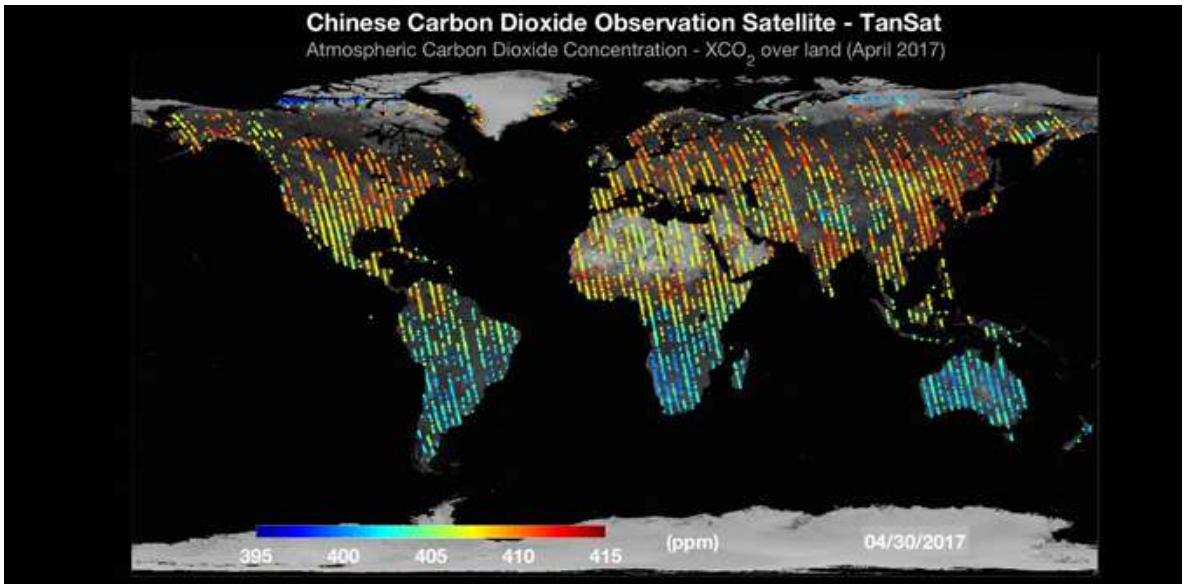
[30] Giriraj Amarnath and others, "Mapping Multiple Climate-related Hazards in South Asia", International Water Management Institute (IWMI) Research Report, No. 170 (Colombo, 2017). Available at http://www.iwmi.cgiar.org/Publications/IWMI_Research_Reports/PDF/pub170/rr170.pdf

[31] Aditya Chaturvedi, "Eye from the sky: Satellites to pinpoint greenhouse emissions and air pollution", *Geospatial World*, 29 July 2019. Available at https://www.geospatialworld.net/article/satellites-greenhouse-emissions/

[32] Francoise-Marie Breon and Philippe Ciais, "Spaceborne remote sensing of greenhouse gas concentrations", *Comptes Rendus Geoscience*, vol. 342, No. 4-5 (April-May 2010). Available at https://www.sciencedirect.com/science/article/pii/S1631071309002399

[33] Thailand Greenhouse Gas Management. Available at http://www.tgo.or.th/2015/english/index.php

Figure 8.2 Data from TanSat showing Carbon Dioxide levels



Source: TanSat Imagery. Figure Provided by National Earth Observation Data Center (NODA), China.
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gas emissions through its own satellite.[34] The data collected by TanSat has helped to improve the understanding of global carbon dioxide distribution, its seasonal variation, and its impacts on climate change. The TanSat team produces global carbon dioxide maps and the chlorophyll fluorescent products, which will assist the global community in carbon monitoring.

In order to further enhance international collaboration on carbon monitoring, the Chinese Academy of Sciences approved the initiation of Cooperation on the Analysis of Carbon Satellites Data (CASA) in 2018.[35] CASA was officially launched in 2019 by ChinaGEOSS-Data Sharing Network. Since then, CASA has been cooperating actively with international entities, such as Group on Earth Observation (GEO), International Science Council, and United Nations Environment Programme (UNEP), in co-funding carbon-oriented scientific researches, through the International Reanalysis Cooperation on Carbon Satellites Data.[36]

4. Collaboration to build capacity towards climate resilience

The on-going pressing challenges of climate change requires all countries to scale up their adaptation efforts and enhance their resilience. However, despite this common challenge, countries are at different stages of maturity in their adaptation capacity with different levels of capabilities. To address this reality, effective capacity-building at national, regional, and

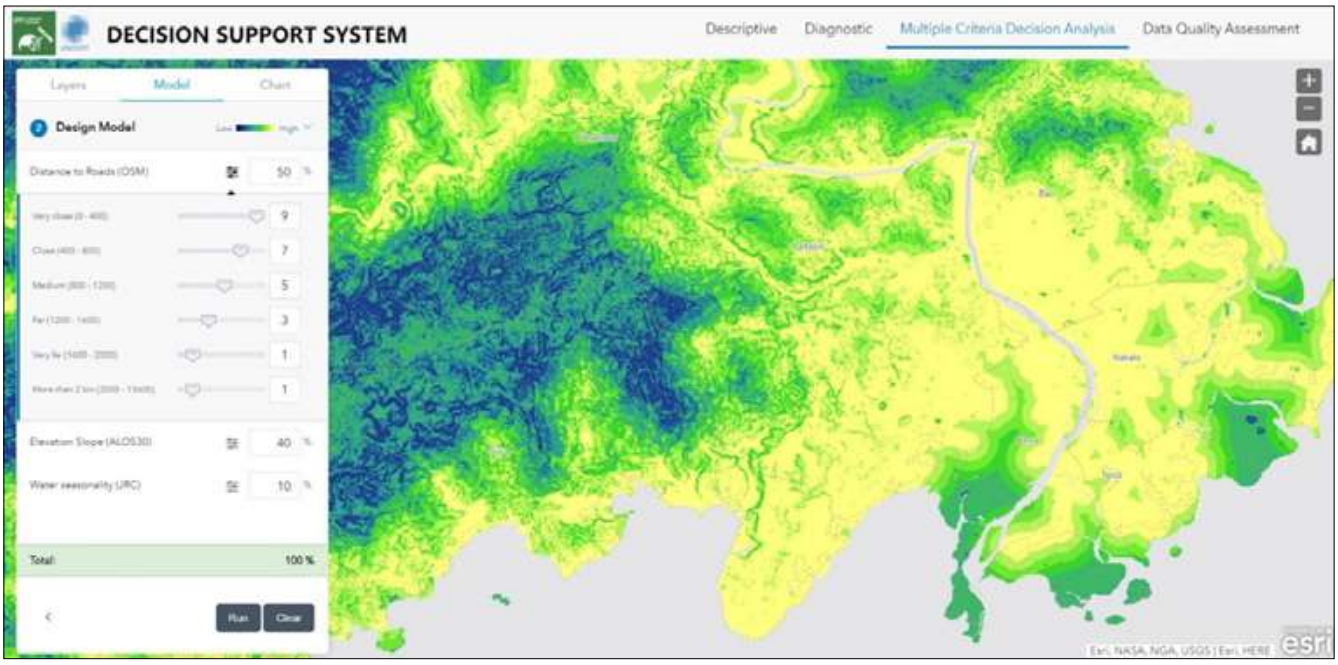
[34] The State Council of the People's Republic of China, "China launches satellite to monitor global carbon emissions", *English.gov.cn* (22 December 2016). Available at http://english.www.gov.cn/news/top_news/2016/12/22/content_281475522238423.htm

[35] Sharing Earth Observation Resources, "TanSat (Chinese Carbon Dioxide Observation Satellite Mission)". Available at https://directory.eoportal.org/web/eoportal/satellite-missions/t/tansat

[36] J. Zhao, and others, "International reanalysis cooperation on carbon satellites data", *Remote Sensing of Clouds and Atmosphere XXIV*, Proceedings SPIE vol. 11152 (9 October 2019). Available at https://www.spiedigitallibrary.org/conference-proceedings-of-spie/11152/111520L/International-reanalysis-cooperation-on-carbon-satellites-data/10.1117/12.2538614.full?SSO=1

Figure 8.3 Decision Support System Landing Page implemented in Esri Experience Builder

Figure 8.4 Multiple Criteria Decision Analysis tool in the Decision Support System platform



Source: IPP, UNOSAT, "Decision Support System".
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subnational level is crucial.[37] Recognizing capacity-building as a fundamental precondition for achieving sustainable development, the Paris Agreement emphasized capacity-building as an important avenue towards climate action.[38] ESCAP also recognises climate change capacity-building as a high priority for its Member States and has outlined, in the Regional Road Map, the opportunities for regional cooperation. This includes promoting capacity-building through sharing experiences and information of existing

[37] Yamide Dagnet, Eliza Northrop and Dennis Tirpak, "How to strengthen the institutional architecture for capacity building to support the post-2020 climate regime", World Resources Institute Publications, December 2015. Available at https://www.wri.org/publication/capacity-building-post-2020-climate-regime

[38] Yamide Dagnet and Eliza Northrop, "3 reasons why capacity building is critical for implementing the Paris Agreement", World Resources Institute Blog, 18 December 2015. Available at https://www.wri.org/blog/2015/12/3-reasons-why-capacity-building-critical-implementing-paris-agreement

mechanisms, and in areas relating to climate change, climate resilience, including climate-related disaster risk reduction. Furthermore, the Plan of Action highlights the need to develop capacity for using space applications for climate related modelling and scenario development. Specifically, for providing technical support in disseminating information and results derived from climate change models and Earth observation data to decision makers and those working at the policy levels.

Moreover, capacity-building should take place not only in the public sector, but also in the private sector. The economies of developing countries are often highly dependent on micro, small, and medium enterprises. The impacts of climate change could be especially devastating, since small-sized businesses tend to be limited in both knowledge and capabilities for implementing adaptations.[39] To bridge this gap, Governments should maintain a leading role and the presence of international organizations can exert significant impacts.

a. International collaboration: Innovative international CommonSensing project

The Pacific Small Island Developing States (SIDS) are directly facing the devastating impacts of climate change. With nearly a third of the population living on land less than 5 meters above the sea level, these islands are particularly vulnerable to the threat of rising sea levels and degrading coastlines.[40]

The innovative international project 'CommonSensing' has been developed by several international partners to aid a group of Pacific SIDS in using satellite remote sensing technology for decision support to help reduce disaster and climate risk. This project is based on a partnership between Fiji, Solomon Islands and Vanuatu, and a consortium of international partners, working together to support and build climate resilience and enhance decision-making. The project is led by the United Nations Institute for Training and Research (UNITAR) through its Operational Satellite Applications programme (UNOSAT), working with the Commonwealth Secretariat, the Satellite Applications Catapult, Devex International, radiant Earth, the United Kingdom Met Office, Sensonomic and the University of Portsmouth.[41]

UNOSAT is currently developing its Decision Support System (DSS) for Disaster Risk Reduction (DRR) and Climate Change Resilience. This DSS will provide contextual analysis of a variety of hazard, risk and vulnerability data, historical disaster losses, and socioeconomic information to support informed decision-making. The users will be taken through a storyline of describing where the risk is, why there is risk and what can be done to reduce it. The solutions are currently being developed using the ESRI ArcGIS Experience Builder technology to provide a modern look and feel. Bandwidth optimisation is also being carried out to ensure seamless experience in context of the Pacific SIDS.

To improve climate resilience for each country, the project approaches capacity-building from two perspectives. First, by developing satellite-based information services that directly match the challenges and needs for each country for improved climate information, disaster risk reduction, and food security. Second, by strengthening access to climate finance and report on climate funds, including national and regional climate action policy.

The multiple criteria decision analysis tool is another important set of tools in the decision support system. It intends to empower the decision maker with an objective evaluation of different DRR options. This will enable the user to set up their own evaluation criteria's, visualise various options for interventions based on those, and assess the best possible action.

b. Armenia: Modernization of hydrometeorological service

To improve resilience to climate change, the Government of Armenia and the Armenian Service for Hydrometeorology are collaborating to enhance the capacity of national hydro-meteorological observation and warning services to ensure adequate forecasting and warning.[42] In 2019, Armenian Service for Hydrometeorology developed the Technical Specifications for Automated Weather Stations (AWS)

[39] Adelphi, "Capacity building and awareness raising on climate change adaptation in the private sector". Available at https://www.adelphi.de/en/project/capacity-building-and-awareness-raising-climate-change-adaptation-private-sector

[40] IPP CommonSensing, "About Us". Available at https://www.commonsensing.org.uk/about-us

[41] IPP CommonSensing. Available at https://www.commonsensing.org.uk/

[42] United Nations Development Programme (UNDP), "Increase resilience of Armenia to climate change through modernization of Armenia's Hydrometeorological service". Available at https://www.am.undp.org/content/armenia/en/home/projects/increase-resilience-of-armenia-to-climate-change-through-moderni.html

together with World Meteorological Organization (WMO) experts and also conducted a comparative analysis on anti-hail protection systems, as requested by the Ministry of Emergency situations.[43]

Specific capacity-building activities have been organized around the following three themes: a) Modernization of the Forecasting System (hardware upgrades and staff training), b) Improving the Warning Infrastructure (maintenance and rehabilitation of the meteorological and hydrological observation networks) and c) Enhancing the Delivery of Services (common standards for the integrated disaster loss management system and digitization of public emergency-related services).

c. The Pacific Islands Regional Climate Center and Pacific Climate Change Portal

The Pacific Island Regional Climate Change Center, more formally known as the World Meteorological Organization Regional Association-V Pacific Islands Regional Climate Centre, provides a regional overview and platform on the state of climate for the Pacific region. The Pacific Island Regional Climate Change Center functions as a base for capacity development and human resource training within the fields of climate change and fills an information gap which allows National Meteorological and Hydrological Services in the region to understand changes in the climate and environment around them.[44]

The Pacific Climate Change Portal is another initiative which provides a database of climate resources which countries within the Pacific can access. Multiple climate related tools are provided within this site which include a traditional knowledge database for weather forecasting, sea level monitoring, ocean data portal and climate planning and assessment tools.[45]

Conclusion

The examples demonstrate the progress, utilizing space-derived information and data, made by countries within the region toward areas related to climate change. As climate change and climate related studies span a variety of fields, it is important to note progress being made within climate modelling and projections, vulnerability and risk mapping, environmental monitoring (including greenhouse gas and carbon emissions) and collaborations within the region to help build capacity toward climate resilience. These proposed actions focus on innovative uses of geospatial information for climate studies and scenario development and play a vital role in contributing to climate related capacity development and sustainable development. Climate change is closely intertwined with many of the other thematic areas, especially with natural disaster risk. If left unmanaged and ignored, climate change has the ability to exacerbate vulnerabilities and undermine development progress within the region. This makes the climate related realm a major challenge in our time and an important field to be acknowledged and built into national policy and planning. Much work still needs to be done within the region to prepare countries for climate related changes and challenges that many people will face in the coming years.

[43] ARNAP, "Comparative analysis on anti-hail protection systems", Report. Available at http://www.arnap.am/?p=9008&lang=en

[44] Angelicas, "Progress made on the Pacific Regional Climate Centre", Secretariat of the Pacific Regional Environment Programme, 8 August 2019. Available at https://www.sprep.org/news/progress-made-on-the-pacific-regional-climate-centre

[45] Pacific Climate Change Portal. Available at https://www.pacificclimatechange.net/

Chapter 9.

Trends and innovative technologies

This chapter explores the trends and technologies that are employed within the Asia-Pacific region, to help provide countries with examples of innovative approaches toward emerging technologies and data. The aim is to help guide countries to actively incorporate innovative responses within their relevant geospatial information applications. The trends described in this chapter focus on the applications of technology, and include examples from countries, space agencies and research institutions.

1. Satellite communications: Background and trends

The first telecommunications satellite manufactured in the United States, Telestar-1, was successfully launched in 1962.[1] During the next 60 years, two dozen satellite constellations and hundreds of individual satellites, that were initially state-owned but have increasingly become commercial, have been launched into orbit for the purposes of broadcasting, monitoring and two-way communication.

[1] TELESAT, "About Us". Available at https://www.telesat.com/about-us/why-satellite/brief-history

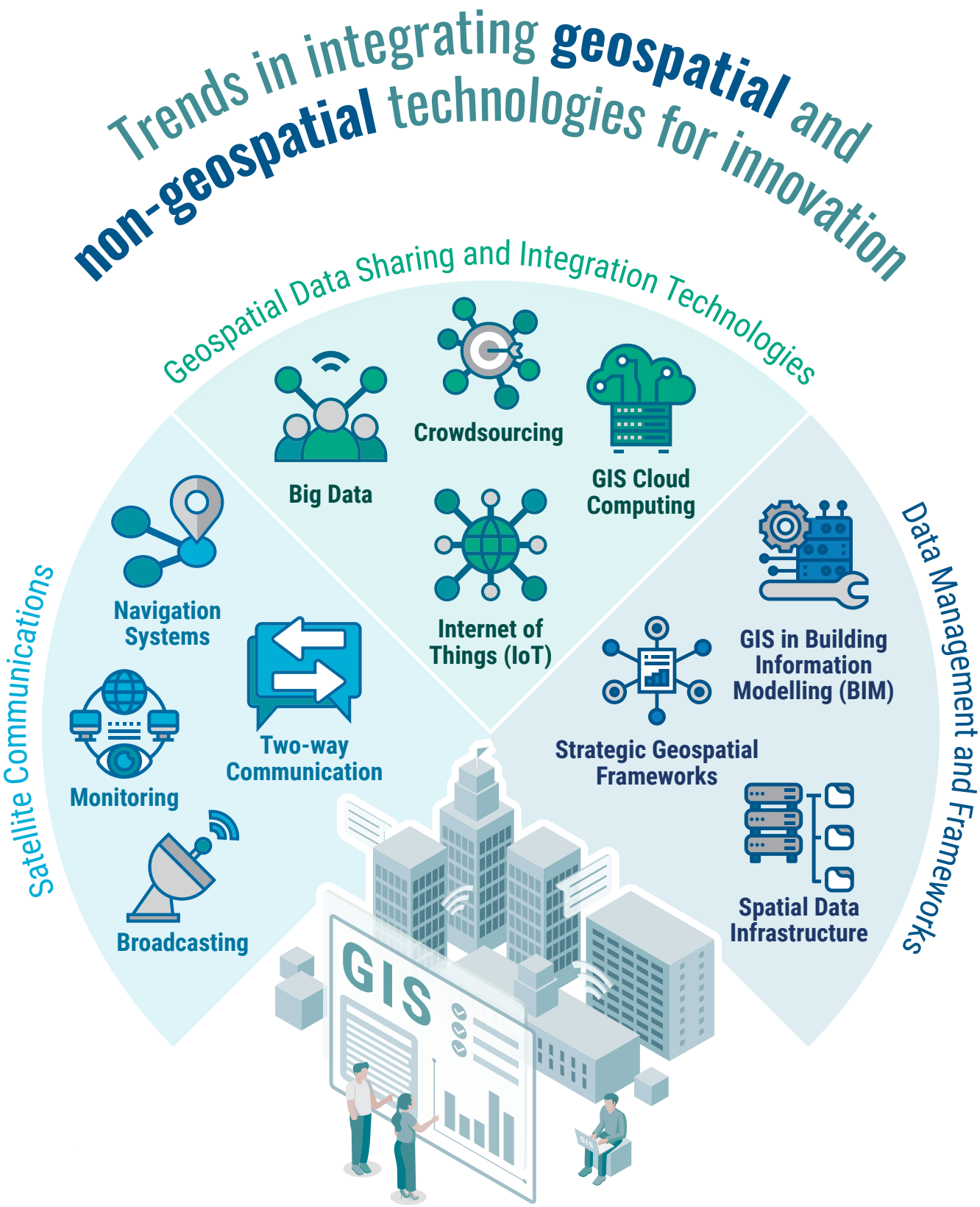

Trends in integrating geospatial and non-geospatial technologies for innovation
Geospatial Data Sharing and Integration Technologies
Big Data
Crowdsourcing
GIS Cloud Computing
Internet of Things (IoT)
Satellite Communications
Navigation Systems
Two-way Communication
Monitoring
Broadcasting
Data Management and Frameworks
GIS in Building Information Modelling (BIM)
Strategic Geospatial Frameworks
Spatial Data Infrastructure
GIS

Figure 9.1 Example of the many satellite constellations orbiting around Earth

Source: Galeria del Ministerio de Defensa de Perú. Available at https://commons.wikimedia.org/wiki/Category:Satellites#/media/File:MINISTRO_DE_DEFENSA_VISITA_MUSEO_CIT%C3%89_DE_I%C2%B4ESPACE_(14428236697).jpg

a. Broadcasting

Presently, ***broadcasting*** satellites are employed to provide 24-hour television and radio services for households worldwide. Most of them are in geostationary orbit at the altitude of 36,000 km above sea level, above a fixed spot on the equator.[2] They receive data from a powerful ground station antenna, rebroadcasting the signal back to the Earth. Such positioning provides consumers with an uninterrupted connection and allows a single satellite to cover more than one-third of the planet's surface.[3]

Geostationary satellites are intended to be deployed for long periods of time due to high capital expenses for manufacturing and orbit deployment. The ones that are defunct are usually transferred to a so-called graveyard orbit, that is approximately 300 km above their regular position.

b. Monitoring

Remote sensing is mostly carried out by Earth observation(EO) satellites employing traditional sensing instruments, such as spectrometers, radars, LiDARs and other passive or active hardware.[4] However, several telecommunication satellite constellations have also been deployed for the purpose of Earth surface ***monitoring***. These solutions are most popular in vessel and aviation tracking for route optimization and in the emergency location of distressed fleet. They are also increasingly used on the ground to facilitate data-intensive operations, such as pipeline monitoring and the remote control of machinery. Several machine-to-machine automatic control systems have been implemented, increasing equipment safety and efficiency, primarily in freight, transportation and the energy sector.[5] Other innovative applications include weather forecasting enhanced by the radio occultation technique,[6] allowing for more accurate forecasting, which is in combination with yet another source of atmospheric data. In the future, with the emergence of the *Internet of Things (IoT)*,[7] the lines between satellite applications will continue to blur, as any device will be able to feed into the broad monitoring ecosystem.[8]

c. Two-way communication

Two-way communication satellite systems are designed to enable telephony and radio services, as well as to deliver a reliable Internet connection. Historically, they have been inferior to ground-based broadband systems in terms of speed and bandwidth,[9] but have proven to be indispensable in remote areas, at sea and during emergency situations.[10] The sector is now expected to see a new life with the significant decrease of launch prices and a general shift from large Geosynchronous Equatorial and Geostationary Orbits and Medium Earth Orbit (MEO) satellites to much smaller Low Earth Orbit (LEO) 'nanosats' and 'cubesats', which have already been deployed in droves by a number of companies striving to pioneer in the largely unchartered waters of the 'worldwide

2 N2YO.com, "Geostationary Satellites". Available at https://www.n2yo.com/satellites/?c=10

3 Electronics Notes, "Geostationary Satellite Orbit, GEO – details of the basics of the geostationary earth orbit, GEO, used by satellites". Available at https://www.electronics-notes.com/articles/satellites/basic-concepts/geostationary-orbit-geo.php

4 EarthData, "Remote Sensors", 6 July 2020. Available at https://earthdata.nasa.gov/learn/remote-sensors

5 Daniel Alsen, Mark Patel and Jason Shangkuan, "The future of connectivity: Enabling the Internet of Things", McKinsey & Company, 29 November 2017. Available at https://www.mckinsey.com/featured-insights/internet-of-things/our-insights/the-future-of-connectivity-enabling-the-internet-of-things

6 Elizabeth Howell, "Shipping companies have a new weather forecast tool using space tech", *Forbes*, 11 September 2019. Available at https://www.forbes.com/sites/elizabethhowell1/2019/09/11/shipping-companies-have-a-new-weather-forecast-tool-using-space-tech/#7486c9ec5e93

7 Link to *IoT section*.

8 Nicolas Hunke and others, "Winning in IoT: It's all about the business processes", Boston Consulting Group (BCG), 5 January 2017. Available at https://www.bcg.com/publications/2017/hardware-software-energy-environment-winning-in-iot-all-about-winning-processes.aspx

9 Business.org, "DSL vs. Cable vs. Fiber vs. Satellite Internet – Compare Internet types", 19 March 2020. Available at https://www.business.org/services/internet/dsl-vs-cable-vs-fiber-vs-satellite/

10 International Telecommunication Union (ITU) and Universal Postal Union – International Bureau (UPU), "Satellite connectivity to remote areas and E-services for development: Initiatives through post office telekiosks in Bhutan", December 2009. Available at https://www.itu.int/en/ITU-D/Technology/Documents/RuralCommunications/Bhutan-Report.pdf

wireless broadband' market. Deploying equipment in lower orbits (around 1,000 km instead of 36,000 km) solves the issue of high connection latency, which has always been the main bottleneck for the mass consumer Internet service.

SpaceX Starlink and small-satellite constellations

SpaceX is in the process of launching hundreds of mass-produced small satellites to provide satellite Internet access. These small satellites will be launched into LEO and work in combination with ground transceivers. Starlink aims to deliver high speed, affordable, broadband Internet access to locations where Internet access has been expensive, unreliable or unavailable, as well as provide competitively priced services to urban areas to satisfy the significant unmet demand for low-cost global broadband capabilities.[11] In August 2020, the tenth Starlink mission was launched, by Space X, which included 57 Starlink satellites, 2 satellites from BlackSky and a spaceflight customer. The potential competitors of Starlink, which have a similar approach of launching hundreds or even thousands of satellites to provide worldwide connectivity, include Amazon's "Kupier", OneWeb, 03b and the Roscosmos "Sphere" project.

These projects aspire to provide affordable connectivity to people living in remote areas, which is beneficial for multiple reasons and will contribute, in many ways, to the achievement of the 2030 Agenda. However, several issues, including space debris and light pollution have arisen and need to be addressed to ensure sustainability of the constellations.

d. Navigation systems

The market for global navigation satellite systems (GNSS) is rapidly expanding with the introduction of more affordable space technology. GNSS refers to the constellation of satellites that provide signals from space transmitting positioning data. GNSS constellations have grown within the previous years and today several space agencies and countries have working regional or global GNSS systems. GNSS constellations can be divided into two groups. In the first group, there are four fully operational satellite systems, which provide uninterrupted positioning data globally. These are GPS from the United States of America, GLONASS from the Russian Federation, "Galileo" from the European Space Agency (ESA) and the most recently operationalized "Beidou"

[11] Starlink. Available at https://www.starlink.com/

from China. The second group consists of regional navigation augmentation systems, which are used for increasing the positioning accuracy in certain parts of the globe and usually operate in tandem with the systems from the first group. The Indian Regional Navigation Satellite System (NavIC) from India and the Quazi-Zenith Satellite System from Japan are the two regional systems that are currently deployed.

Japan's Quazi-Zenith Satellite System (QZSS)

The QZSS is a regional navigation satellite positioning system commissioned by the Government of Japan, under the Japan Aerospace Exploration Agency (JAXA). QZSS has been operating as a four-satellite constellation since November 2018. The system is designed so that three satellites are visible at all times over the Asia-Pacific region. The three QZSS satellites have been positioned to increase accuracy and positioning and provide satellite navigation in areas that challenge traditional GNSS systems, such as in cities or obstructed environments. QZSS is compatible with GPS and can be used in an integrated way to ensure high precision positioning even in urban canyons and mountainous areas.

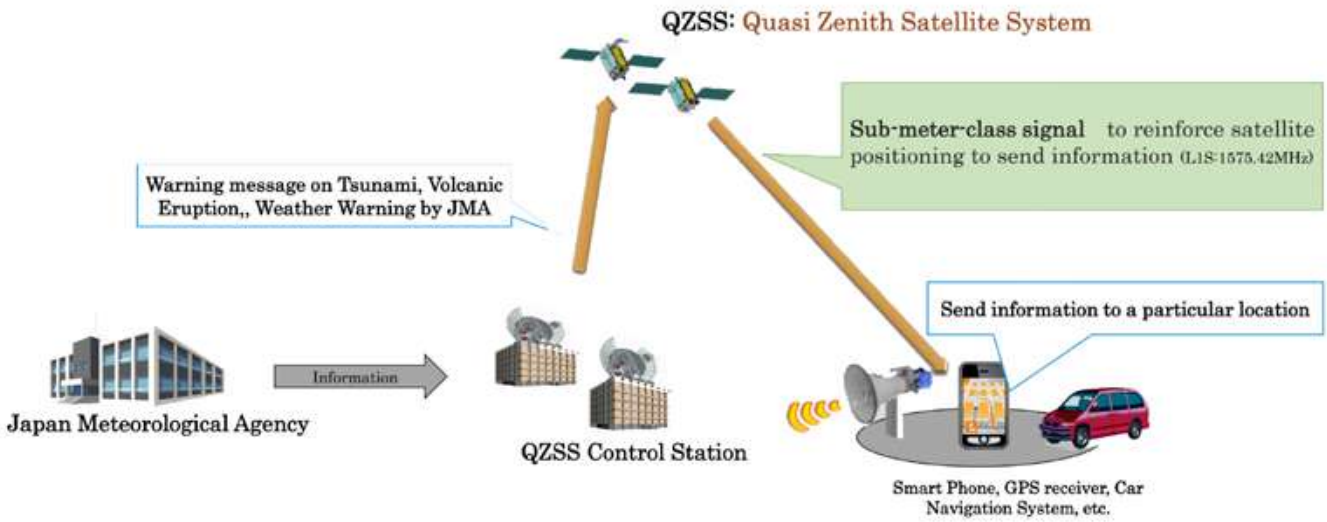
The Government of Japan is integrating part of the QZSS for use as an emergency management information system. They have started to prepare and test a disaster early warning system which aims to better predict disasters in the Asia-Pacific region.[12] This is done by sending a warning message through a signal from the QZSS control station to the QZSS satellites, which then send this information to specific ground locations through smartphones, car navigation devices and other GNSS receivers.[13]

While QZSS was developed primary for users in Japan, the orbit design offers significant advantages to other countries in the region, including Australia. Due to its geographic location, as demonstrated in Figure 9.3, GNSS users in Australia are able to connect to QZSS for more accurate GNSS positioning. Research has already been undertaken, in Australia, using QZSS for precision agriculture and researchers have found that QZSS provides centimetre-level accuracy. QZSS can offer huge potential to Australia in terms of reaching numerous industries that can utilize GNSS data, possibly including new sectors. For example, QZSS can aid in areas with sparse GNSS ground stations and in zones with limited mobile network coverage. This is important for many rural and outback areas where building and operating additional GNSS ground stations, which are needed for higher accuracy, is costly.

[12] United Nations Office for Outer Space Affairs (OOSA), "Japan prepares to test early warning using Michibiki satellites", 30 January 2019. Available at https://reliefweb.int/report/japan/japan-prepares-test-early-warning-system-using-michibiki-satellites

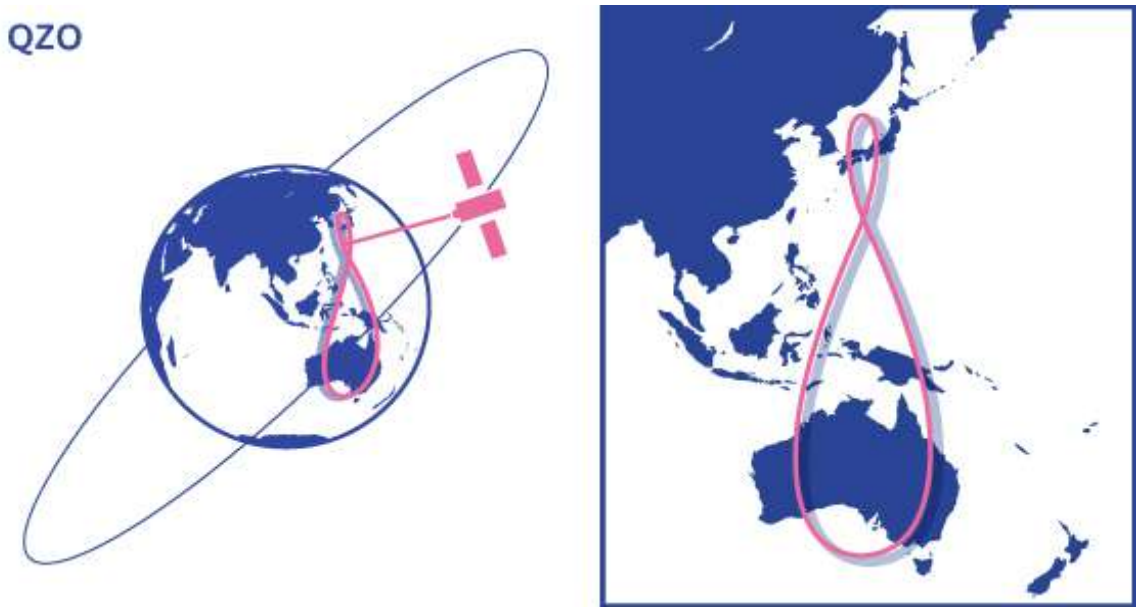
[13] Asia-Pacific Economic Cooperation (APEC), Asian Disaster Reduction Center, "QZSS (Quasi Zenith Satellite System) for Early Warning Message Platform", 12th Senior Disaster Management Official Forum (Papua New Guinea, 25-26 September 2018). Available at https://www.apec-epwg.org/media/2252/888a4b362a2f243cf59ed91f0b6c4057.pdf

Figure 9.2 The role of QZSS in emergency management services in Japan



Source: Presentation by Koji Suzuki, Asian Disaster Reduction Center (ADRC).

Figure 9.3 Satellite orbit of QZSS



Source: JAXA. Available at https://qzss.go.jp/en/technical/technology/orbit.html
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

2. Geospatial data sharing and integration technologies

a. New technologies and sources in integrating geospatial information

As geospatial data and information is diverse and being created daily, it can be used within a wide range of fields. Thus, it is increasingly necessary to integrate geospatial information within multiple sources and data formats. Doing so allows datasets from different sources to correct, refine and enrich each other. For example, existing road maps can be used to help identify new roads from new satellite images. Additionally, it can allow the monitoring and generation of new insights in areas, such as resource management and disaster resilience, based on integrated data that measures the current situation at multiple levels.

At the same time, a trend for integrating geospatial information is the inclusion of novel data sources and technologies, such as Big Data, Internet of Things (IoT), crowdsourcing and cloud computing. Such approaches give rise to new opportunities and challenges in the field, and in this section, a brief summary of trends in this area will be explored together with relevant country practices.

Box 6 Fupin Cloud, China

'Fupin Cloud' (literally translated as 'poverty alleviation cloud'), in the Guizhou province of China, provides an excellent example of how Big Data helps cross-sector stakeholders in making decisions. Developed by the Poverty Alleviation Office in Guizhou Province, 'Fupin Cloud' is a GIS-based platform which records the information of every poor household in the province. This data is overlaid with other geospatial data, including geometry, industry, house, population and income. It helps the Government in locating poor households for poverty alleviation, by recording such information and by statistical and spatial analysis that evaluates the levels of poverty and that sheds insights (for example on disease, education, housing, disaster, access to public services) into the potential reasons for poverty. Such analysis further assists stakeholders in tailoring regional poverty alleviation strategies.[a, b, c].

[a] For more information see The People's Republic of China, The State Council, English.Gov.Cn. Available at http://www.gov.cn/xinwen/2016-04/05/content_5061203.htm

[b] Yong Ge and others, "Mapping annual land use changes in China's poverty-stricken areas from 2013 to 2018", Remote Sensing of Environment (2019). Available at https://www.x-mol.com/paper/5763790

[c] Yong Ge and others, "Space–time variability analysis of poverty alleviation performance in China's poverty-stricken areas", Spatial Statistics, vol. 21, No. 17 (2017).

b. Big Data

Big Data is defined as both structured and unstructured datasets that have great volume. Because of this trait, it cannot be managed easily with traditional methodologies and has its own features, which are commonly summarized by the phrase, Volume, Variety and Velocity (3V).[14] Additionally, much (arguably 80 per cent) of the Big Data can be geo-referenced,[15] which gives rise to the possibility of integrating it with geospatial applications and analysis. There is a myriad of data sources, some of which include data commonly collected by drones or satellites, crowdsourcing (for example, the OpenStreetMap open data project) and social media (for example, geo-coded tweets that attribute information to a location).

The usage of Big Data may benefit geospatial analysis for a wide range of development priorities. Because of the massive amount of data available, it can produce real-time, in-depth analysis more precisely, or at a larger scale, than using traditional geospatial data or surveying methods. Such analysis benefits both end-users and stakeholders by guiding decision-making and helping to tailor development strategies. As a result, multiple countries in the Asia-Pacific region, such as Australia (Open Data Cube technology),[16] China and the Republic of Korea initiated the research of Big Data usage and the development of Big Data platforms, at national or sub-national level, as a way of advancing geospatial applications.

However, it is worth noting that geospatial Big Data poses both societal and technological challenges.[17] Firstly, data security and privacy may be a problem in terms of data management and usage. This can become problematic if sensitive data is hosted through external servers or platforms 'on the cloud'. Secondly, the massive scale of data itself is a challenge for the storage, management, processing, analysis, visualization and verification of the data, especially for countries that lack adequate software and hardware capabilities for managing such large scales of data and information. This may require the integration of other existing and emerging technologies, such as IoT and crowdsourcing for data collection, cloud platforms for data processing, and infrastructure for data management and storage.

c. Internet of Things (IoT)

The Internet of Things (IoT) are technologies and related research that deals with real-world objects connected to the Internet.[18] They are equipped with sensors that precisely measure the physical world and exchange data among themselves. As such data contain detailed geographical information, location-aware IoT devices play an important role in multiple aspects of geospatial data applications. As the cost of sensors decreased significantly during the past decades, IoT is spreading rapidly and one can expect to witness growth in its scale and usage in geospatial applications. For example, there were approximately 230 million cellular Machine-to-Machine subscriptions for IoT applications in 2015, and the number is estimated to be 26 billion in 2020.[19]

Major areas that take advantage of IoT are health care, manufacturing, energy systems, transport systems, disaster prevention, smart cities and urban infrastructure, and smart government, according to the Organization for Economic Co-operation and Development (OECD).[20] For example, Japan used sensor webs to provide early earthquake warnings.[21] Additionally, China used a real-time bridge maintenance and monitoring system, based on the Beidou high-precision positioning and IoT technology to monitor the 'health status' of its bridges. The system can provide on-site data collection to the construction unit during the bridge construction period and for daily monitoring, early warning, auxiliary decision-making information and maintenance planning to

[14] Jae-Gil Lee and Kang Minseo, Kang, "Geospatial Big Data: Challenges and Opportunities", *Big Data Research*, vol. 2, No. 2 (June 2015). Available at https://www.sciencedirect.com/science/article/pii/S2214579615000040?via%3Dihub

[15] Caitlin Dempsey, "Where is the phrase '80% of data is geographic" from?", GIS Lounge, 28 October 2012. Available at http://www.gislounge.com/80-percent-data-is-geographic/

[16] Australian Government, Geoscience Australia, "Digital Earth Australia". Available at https://www.ga.gov.au/dea/odc

[17] Songnian Li and others, "Geospatial big data handling theory and methods: A review and research challenges", *ISPRS Journal of Photogrammetry and Remote Sensing*, vol. 115 (May 2016). Available at https://www.sciencedirect.com/science/article/abs/pii/S0924271615002439?via%3Dihub

[18] Andreas Kamilaris and Frank O. Ostermann, "Geospatial Analysis and the Internet of Things", *ISPRS International Journal of Geo-Information*, vol. 7, No. 7 (2018).

[19] United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), "Frontier technologies for sustainable development in Asia and the Pacific". Available at https://www.unescap.org/sites/default/files/publications/Frontier%20tech%20for%20SDG.pdf

[20] Organization for Economic Co-operation and Development (OECD), "OECD Science, Technology and Innovation Outlook 2018", 19 November 2018. Available at http://www.oecd.org/sti/oecd-science-technology-and-innovation-outlook-25186167.htm.

[21] David Talbot, "80 seconds of warning for Tokyo: Earthquake-detection technology investment pays off for Japan", *MIT Technology Review*, 11 March 2011. Available at https://www.technologyreview.com/2011/03/11/119454/80-seconds-of-warning-for-tokyo/

the supervisors and owners of the bridge, hence enhancing the safety of urban infrastructure.[22]

IoT needs technology architecture to gather and connect data points to enable applications in socioeconomic aspects. In practice, IoT sensor-generated data is commonly combined with cloud computing and Big Data analytics technologies.

d. Crowdsourcing

Geo-crowdsourcing, or *Volunteered Geographical Information (VGI)*, describes a new data source in geospatial informatics where spatial data is voluntarily and collaboratively collected by a large group of users instead of by professionals. The data is based on personal measures or personal knowledge that is reported via certain platforms. The availability of such data collection methods comes from the growth of the Internet over the last two decades, as well as advancements in geotechnology, such as location-aware mobile devices, cameras and mapping software.[23] This makes the production of decentralized, user-generated geospatial content, at a massive scale, possible and gives rise to new possibilities of how geospatial information can be produced, stored and used. Existing projects can apply these methods to generate a wide range of geographical data including, but not limited to, building imagery, attributing information to locations and collecting paths and traces.[24]

The potential benefit of VGI is apparent: the scale of end-users and its often-voluntary nature enable massive amounts of geospatial information to be collected at a relatively low cost. Such benefits are attracting the attention of both end-users and stakeholders such as governments, so as to inform policy decisions and operations.

VGI is becoming more prevalent within the development sector, with NGOs and organizations setting up mapathons and mapping projects to try and create data to aid in relief efforts. For example, Missing Maps is an organization which is engaging community volunteers and humanitarian organizations to help map and trace street level detail. This is usually done through online open source software, such as OpenStreetMap (OSM).[25] These mapathon events are usually held at the community or local level, bringing together volunteers who can learn about mapping while also helping to create data and improve vulnerable areas.[26]

The crowdsourcing method, similar to other cutting-edge trends, is facing both challenges and opportunities. The first major challenge lies in user engagement for those who want to adopt the method, as the data can only be sufficient with a significant mass of users generating content actively. Tackling this problem requires efficient strategies to motivate participants, (such as providing mobile phone credits in exchange for sending data) and a careful design of assigned tasks, as the users need to be both motivated toward and capable of performing the data-collection tasks. The second challenge is data quality. Malicious content and vandalization may still be a problem. Data validation strategies are still necessary for collecting and using crowdsourced data.

[22] Lin Xue, "Monitoring bridge health, preventing gas leakage... 'Beidou+' affects more and more industries", *Yangzi Wanbao News*, 4 June 2019. Available at https://t.cj.sina.com.cn/articles/view/1653603955/628ffe7302000lz1w?from=tech

[23] Daniel Sui, Sarah Elwood and Michael Goodchild, eds., *Crowdsourcing Geographic Knowledge: Volunteered Geographic Information (VGI) in Theory and Practice* (Netherlands, Springer, 2013).

[24] Defense Technical Information Center, "Crowdsourced Geospatial Data: A Report on the Emerging Phenomena of Crowdsourced and User-Generated Geospatial Data". Available at https://apps.dtic.mil/dtic/tr/fulltext/u2/a576607.pdf

[25] Missing Maps. Available at https://www.missingmaps.org/

[26] Vivien Deparday, Jocelyn Michele West and Mira Lilian Gupta, "The rise of local mapping communities", World Bank Blogs, 7 November 2018. Available at https://blogs.worldbank.org/sustainablecities/rise-local-mapping-communities-for-resilience

Box 7 Smart Complaint System in the Republic of Korea

A smart complaint system was developed for the metropolitan citizens of the Republic of Korea to submit their complaints about road damage, illegally dumped garbage and illegal parking. The complaint is uploaded via a smartphone app. Each upload contains a geographic location, information and images of the situation.[a] A citizen can take pictures of the situation and submit it online in real-time with relevant information and images with their cell phone. The data collected from end-users is first delivered to the relevant official staff for resolution, and the users can track the resolution process with the same application. Additionally, the data collected is also analysed together with authoritative data to inform future municipal and region-level policy decisions and operations.

[a] Seoul Metropolitan Government, "Seoul City Complaints now 'Smart Reported'", 8 March 2012. Available at http://english.seoul.go.kr/seoul-city-complaints-now-%E2%80%98smart-reported%E2%80%99/

e. GIS Cloud Computing

GIS Cloud Computing, a type of virtualized, computing resources provision, based on service-level agreements, uses Cloud Computing platforms for GIS analysis.[27] Cloud computing provides technological capabilities via standard Internet protocols, meaning that users do not need sophisticated hardware or software. Users do not own the asset, but pay for their access to a wide range of computing and storage services, such as the Google Earth Engine or ESRI's ArcGIS Online. Such traits make cloud computing scalable and elastic, compared to traditional computational services.

Meanwhile, GIS has made use of the cloud computing platform by shifting many of its functions into the cloud. Through GIS's adoption of cloud, the flexibility and scalability of the cloud environment can benefit data capture, visualization, analysis and sharing by making it easier for GIS to integrate geographical information from multiple sources.

For the Sustainable Development Goals targets and for the benefit of Governments and stakeholders, these services can be used in a wide range of areas, from emergency response to traffic management.[28] For example, in terms of disaster risk resilience, researchers suggest that cloud computing infrastructure may be used for disaster detection and environmental monitoring. Moreover, as cloud computing can store data at a centralized data hub instead of at a local disk drive, it allows data backup for business continuity when a disaster strikes.

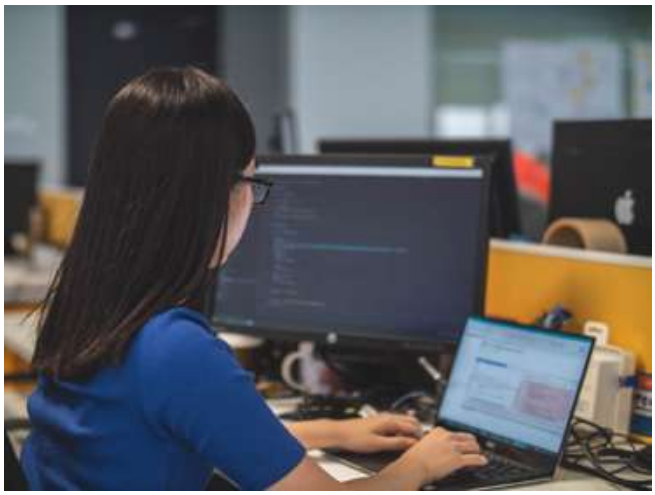
Many good examples of GIS cloud computing, through online geospatial portals and online data sharing hubs, have been shown through the country practices mentioned in previous chapters.[29]

Inter-connection between new technologies

The integration of frontier technologies is an essential part of a holistic sustainable development approach. The technologies and data sources introduced here should be integrated in order to help countries use and manage their geospatial data. VGI and IoT funnel human and machine-generated Big Data, cloud computing offers the capacity and infrastructure for the data to be stored and further analysed online, and Big Data Analytics empowers data processing and decision-making. In combination, these technologies allow massive amounts of geo-referenced data from novel sources to be integrated with other types of data to generate new insights.

Digital divide

Existing challenges and inequalities become more apparent with the introduction of novel technologies, especially when it comes to digital hardware and software access. Several countries in Asia and the Pacific lack access to even basic Internet connectivity. With the new wave of digital innovations, it is vital that these less connected countries have access, support and guidance so that they can benefit from these innovative technologies. For example, eight Pacific Island countries had less than 2 per cent or lower fixed-broadband penetration in 2016.[30] If these countries do not have access to broadband services, they will lack access and opportunities to many emerging technological trends.



3. Data management and frameworks

Geospatial data management offers effective and reliable ways for users to obtain, query, organize, store, analyse, share and visualize geospatial data. Geospatial data management has achieved great development with the boost in cutting-edge data management technologies, including Big Data and cloud computing. Meanwhile, geospatial data management will expand its range of applications,

[27] Omar Al-Bayari, "GIS Cloud Computing Methodology", Institute of Electrical and Electronics Engineers, 2018. Available at https://ieeexplore.ieee.org/document/8440176

[28] United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), "Frontier technologies for sustainable development in Asia and the Pacific". Available at https://www.unescap.org/sites/default/files/publications/Frontier%20tech%20for%20SDG.pdf

[29] For example, see Cropwatch Box in Chapter 4.

[30] United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), "Broadband connectivity in Pacific Island Countries", Asia-Pacific Information Superhighway (AP-IS) Working Paper Series (January 2018). Available at https://www.unescap.org/sites/default/files/Broadband%20Connectivity%20in%20Pacific%20Island%20Countries.pdf

especially in the integration of geospatial data and statistical data and in Building Information Modelling.

a. Spatial Data Infrastructure

Because of the inconsistency of geospatial data formats and geospatial coordinate systems, a unified spatial data infrastructure (SDI) is needed for users. A spatial data infrastructure includes an efficient and flexible data framework and relevant technologies that provide guidelines and principles for connecting geographic data, metadata, users and tools. To meet national geospatial development needs, many countries have proposed their own National Spatial Data Infrastructure (NSDI). The National Spatial Data Infrastructure is the entity responsible for the technology, policies, standards, human resources and related activities necessary to acquire, process, distribute, use, maintain and preserve spatial data throughout all levels of government, private and non-profit sectors and academia. It provides a structure of relationships among data producers and users and focuses on processes that facilitate data sharing.[31] The key function of SDI is interoperability. The interoperability enables different formats of geospatial data to be connected, exchanged, accessed, and used in different systems, applications and devices in a coordinated manner by stakeholders. The NSDI can improve the accessibility to geospatial data and reduce the costs in geospatial data generation and maintenance.

In the Asia-Pacific region, Australia, China, Japan, the Republic of Korea and the Russian Federation are in the leader bloc with an effective and advanced National Spatial Data Infrastructure.[32] India, Indonesia, Malaysia, Philippines and Thailand are in the medium stage with a NSDI that can provide collection of geospatial data services through geoportals. However, the data is only partially open and free for the public. Meanwhile, other countries in Asia and the Pacific are either still implementing their NSDI projects or are yet to begin. This unevenness of Spatial Data Infrastructures in the Asia-Pacific region shows that the region still has much room to develop and grow.

[31] United Nations Office for Outer Space Affairs, "Jamaican National Spatial Data Infrastructure (NSDI)". Available at http://www.un-spider.org/links-and-resources/institutions/jamaican-national-spatial-data-infrastructure-nsdi

[32] GEOBUIZ, Geospatial Industry Outlook and Readiness Index, "GeoBuiz 2019 Report". Available at https://geobuiz.com/geobuiz-report-2019/

Box 8 The Russian Federation's National Spatial Data Infrastructure (NSDI)

The NSDI is developed and synchronised by the Federal Service for State Registration, Cadastre and Cartography. The infrastructure is comprised of four data funds under continuous development: the federal spatial database, databases of government entities, the Defense Ministry data fund and regional databases.

Effective and agile management of available information (maps, cadastral information, geodetic and topograhic measurements, etc.), is one of the Service's top priorities. For example, if a certain region cannot maintain its own data centre, a cluster in the federal database can be allocated to the region.

Ordinary citizens from the Russian Federation can also benefit from the country's NSDI. For instance, estate owners can request detailed cadastral data about their land. Businesses and the broader public can use the Public Cadastral Map service, which is an online map where all the territories are delineated on a very low level. A high level of detail has been achieved thanks to the decentralized nature of cadastral activities in the country. In particular, small private firms and individual specialists carry out the delineation of small to medium-sized territories. This creates a competitive and decentralized data collection ecosystem, while lessening the burden on government agencies and allowing them to focus on the efficiency of the NSDI.

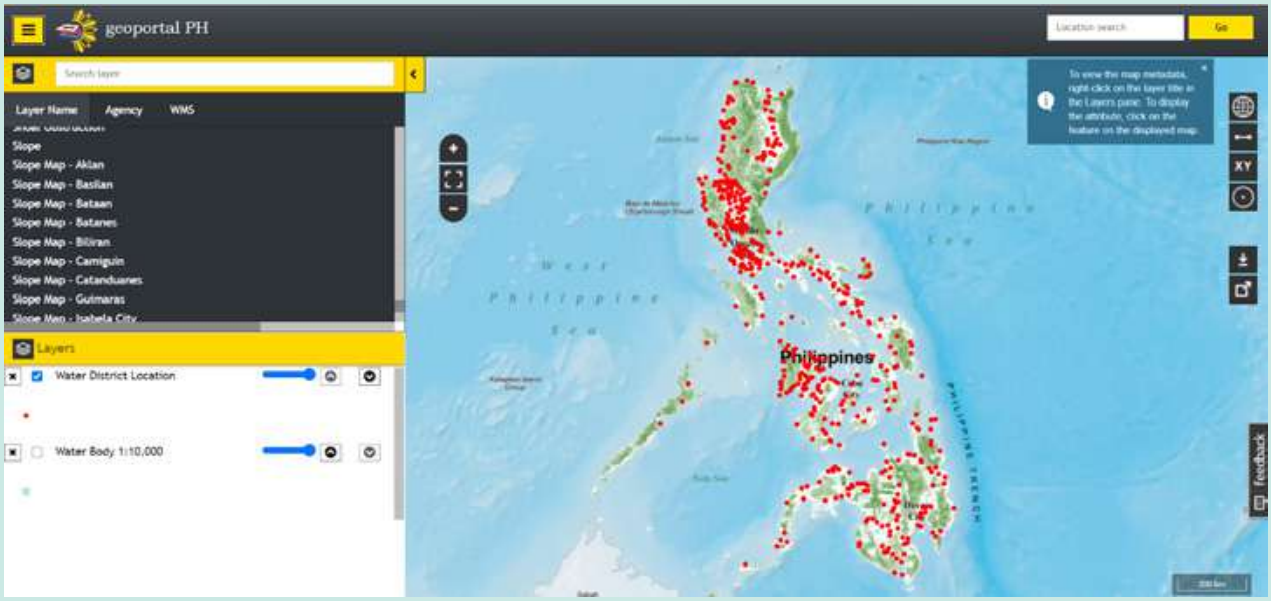
The development of NSDI is a continuous process. With new technologies emerging, the NSDI needs to adapt to these new technologies to meet real world demands. Even countries in the leader bloc need to strengthen their NSDI development. In China's National Overall Planning on Land Use (2016-2030), the State Council includes the objective of strengthening geospatial infrastructures for the development of the EO system and the information highway.[33] The State Geospatial Information Center in China, is pushing forward the open source and

[33] State Geospatial Information Center, "State Geospatial Information Center Introduction". Available at http://sgic.geodata.gov.cn/web/sgic/xggh-kjgh/info/2018/2700.html

Box 9 Philippines Geopoartal - One Nation One Map

The Geoportal Philippines provides an ICT platform for collaboration, data and resource sharing, transparency and resource optimization. Led by the National Mapping and Resource Information Authority, the established web portal provides a system for the sharing of and access to geospatial information using one common multiscale basemap. Geoportal Philippines intends to hold and serve the general public using the basemaps and fundamental datasets that the National Mapping and Resource Information Authority produces and the thematic datasets of other stakeholder agencies. It also promotes the participation of local government units who have mandate to produce subnational level geospatial data, such as land use plans, which is otherwise not carried out by the national government agencies. As of July 2020, the system holds 1,243 thematic layers. The continual build-up of data content, development of GIS-based applications, and development of agency/sectoral node portals remains a priority in this undertaking.

Figure 9.4 Geoportal Philippines



Source: Geoportal Philippines Available at http://www.geoportal.gov.ph/
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

market applications of its database.[34] In January 2019, the State Geospatial Information Center signed a cooperation agreement with Xi'an Dadi Survey and Mapping Co., Ltd., aiming to combine the strength of NSDI and private enterprises for the diversification of geospatial information applications.

b. The Global Geodetic Reference Frame (GGRF)

Geodesy is the measurement of the variations in Earth's shape, rotation, and gravitational field. Geodesy provides a necessary point of reference that makes the consistency of any measurements possible. Recognizing the significance of Geodesy, the Global Geospatial Information Management (UN-GGIM) established the Working Group for a Global Geodetic Reference Frame (GGRF). GGRF now serves as the foundation for collecting and managing national and global geospatial information. As a key requirement for spatial data interoperability, GGRF plays important roles in activities ranging from civil engineering, agriculture, to financial transactions and scientific research. Important issues in sustainable development, such as land use, disaster assessment, and emergency response also require the support of GGRF.

[34] State Geospatial Information Center "The center held symposium on the operation and maintenance of the national natural resources and geospatial basic information database", 27 September 2018. Available at http://sgic.geodata.gov.cn/web/sgic/zxdt18/info/2018/3227.html

c. The Integrated Geospatial Information Framework (IGIF)

All sectors within any country have a need for reliable geospatial information and EO data for national development. They are critical components of the national infrastructure, serving as a nation's blueprint of what happens where and as the means to integrate a wide variety of data, so that Governments are able to ensure economic growth, national security, social development sustainability, environmental sustainability and national prosperity. With an emphasis on 'all countries' being able to measure and monitor development progress with good policy, science, technology and especially data, the SDGs are highly dependent on geospatial information. However, the provision of geospatial information and technologies to support implementing the SDGs has not yet been adequately applied and mainstreamed by countries, as they simply do not have the appropriate frameworks, guidance and methodologies to do so.

To help Member States overcome these challenges, the United Nations Committee of Experts on Global Geospatial Information Management (UN-GGIM) is advancing and securing the future role of geospatial information and EO to support the implementation of the SDGs through the United Nations Integrated Geospatial Information Framework (IGIF).[35]

Developed by the United Nations and the World Bank, the IGIF provides a basis and guide to develop, strengthen and integrate national geospatial information strategies, data, systems, tools, services and capabilities, to take practical actions to achieve digital transformation, and bridge the geospatial digital divide in the implementation of national priorities and in the 2030 Agenda for Sustainable Development.

The IGIF translates high-level concepts to practical implementation guidance and actions. It does this by leveraging seven underpinning principles, eight goals, and nine strategic pathways as a means for Governments to establish and coordinate, strengthen and sustain more effective integrated geospatial information management arrangements. The objective of the nine strategic pathways is to guide Governments towards implementing integrated geospatial information management nationally and in a transformative way, thereby accelerating national efforts to deliver a vision for sustainable social, economic and environmental development.

[35] United Nations Committee of Expert on Global Geospatial Information Management (UN-GGIM), "Integrated geospatial information framework (IGIF)". Available at http://ggim.un.org/IGIF/

The IGIF comprises of three separate documents that are nonetheless interconnected as well:

Part 1: The Overarching Strategic Framework is forward-looking, built on national needs and circumstances for Member States. It sets the context of 'why' geospatial information management is a critical element of national social, environmental and economic development.[36]

Part 2: The Implementation Guide, is detailed with specific options and actions for each of the nine strategic pathways. It is a reference for Governments to implement integrated geospatial information management in such a way that is transformational, visible, and sustainable.

Part 3: The Country-level Action Plan answers the questions 'how, when and who' to allow countries to implement the IGIF through their self-developed Country-level Action Plan that considers national circumstances and priorities. A number of countries are already developing and implementing their own national Action Plans.

d. The Global Statistical Geospatial Framework (GSGF)

Over 80 per cent of Big Data maps are linked to geographic locations. Hence, an increasing number of plans and projects of integrating geospatial information and statistical data have been proposed for leveraging advantages in geospatial data. As a result, the United Nations Committee of Experts on UN-GGIM developed the Global Statistical Geospatial Framework (GSGF), a high-level framework on the integration of statistical and geospatial data,[37] which is designed to connect socioeconomic and environmental data through location and provides principles and guidelines in the standards, tools and methods.

Since the inputs of GSGF include geospatial and statistical data, the former contains the GGRF, address data, building and settlements data, while the latter contains crowdsourcing and Big Data sources as complementary inputs. The basic principles are shown in Figure 9.5. The outputs and results of

[36] The Overarching Strategic Framework of the IGIF was adopted by UN-GGIM at its eighth session in August 2018. See Decision 8/113, E/2018/46-E/C.20/2018/19. Available at http://ggim.un.org/meetings/GGIM-committee/8th-Session/documents/Part%201-IGIF-Overarching-Strategic-Framework-24July2018.pdf

[37] United Nations Expert Group on the Integration of Statistical and Geospatial Information, "Global Statistical Framework: Linking statistics and place – current status and plans for development", July 2018. Available at https://unstats.un.org/unsd/statcom/51st-session/documents/The_GSGF-E.pdf

Box 5 The Kingdom of Tonga's National Action Plan

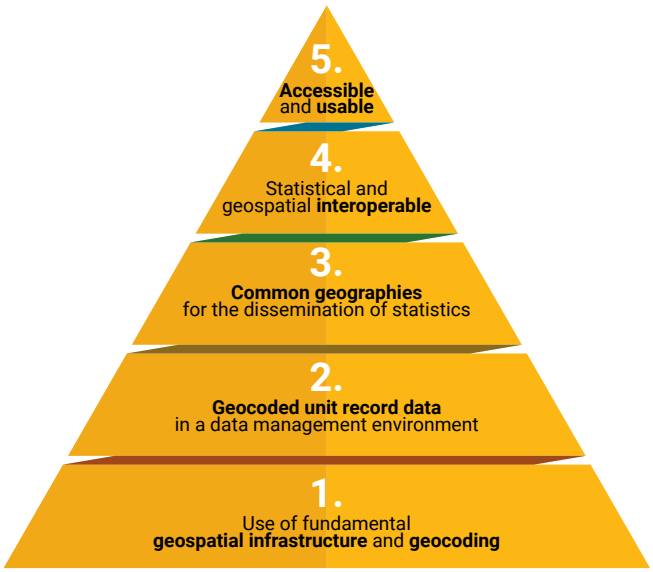
The Kingdom of Tonga has successfully developed their National Action Plan.[a] The aim of Tonga's Action Plan is to provide the most appropriate and relevant actions to support and strengthen Tonga's geospatial information management capabilities, and to make decisions about how to prioritize and resolve strategic geospatial gaps through actions.

One of Tonga's first activities was to develop a Needs Assessment and Gap Analysis Report. Through these mechanisms, Tonga was able to: articulate its collective vision, goals and its stakeholders for integrated geospatial information management; review the current state of geospatial information and identify the challenges; develop strategies of action to minimize or solve the gaps; and improve the state of integrated geospatial information management. Finally, Tonga has aligned the national Action Plan with local, national, regional and international strategic goals, developing their seven strategic goals within the national Action Plan on integrated geospatial information.

[a] The Kingdom of Tonga, "Joint National Action Plan on Climate Change Adaptation and Disaster Risk Management 2010-2015, Second National Communication Project, Ministry of Environment and Climate Change and National Emergency Management Office, Tonga.

GSGF can be leveraged for data-driven and evidence-based decision-making to support local, sub-national, national, regional and global development priorities of the 2020 Round of Population and Housing Censuses and the 2030 Sustainable Development Agenda.[38]

Figure 9.5 The five principles of GSGF



Source: United Nations Committee of Expert on Global Geospatial Information Management (UN-GGIM), "The Global Statistical Geospatial Framework" (New York, 2019). Available at http://ggim.un.org/meetings/GGIM-committee/9th-Session/documents/The_GSGF.pdf

[38] United Nations Committee of Expert on Global Geospatial Information Management (UN-GGIM), "The Global Statistical Geospatial Framework" (New York, 2019). Available at http://ggim.un.org/meetings/GGIM-committee/9th-Session/documents/The_GSGF.pdf

The Global Statistical Geospatial Framework is flexible and can be adapted to various countries and regional contexts. Australia and New Zealand have developed similar national frameworks. Good practices from these countries can be adopted by other countries and prove the operability and practicality of GSGF. The GSGF and the IGIF mutually complement and interact with each other and both frameworks are enablers for broader and more practical geospatial ecosystems.

e. GIS in Building Information Modelling (BIM)

Building Information Modelling (BIM) is a digital representation of the physical and functional characteristics of a facility. A BIM is a shared knowledge resource for information about a facility, forming a reliable basis for decisions during its life-cycle, which is defined as existing from its earliest conception to demolition.[39] BIM is transforming the computer-aided drafting (CAD) products towards 3D models.

The 3D modelling technologies in GIS facilitate the evolution towards 3D building information modelling, GeoBIM, which is an integration of GIS and BIM. 3D models can help users access a more accurate representation of buildings and infrastructure.[40] With the integration of GIS, the BIM models can be blended into geospatial contexts or be included in

[39] National BIM Standard – United States™ Version 2, "Frequently asked questions about the National BIM Standard – United States™". Available at https://web.archive.org/web/20141016190503/http://www.nationalbimstandard.org/faq.php#faq1

[40] Chris Andrews, "GIS and BIM integration leads to smart communities", esri, Spring 2018. Available at https://www.esri.com/about/newsroom/arcuser/gis-and-bim-integration-leads-to-smart-communities/

geospatial analysis in other applications, such as city planning. For example, GIS can provide useful information for city planning in disaster-prone areas, counselling building designers on selecting locations, orientations, construction materials and even the number of floors. GIS-leveraged 3D BIM models can evaluate the effects of building height in air routes or overpass and thus improve the planning of road, airports and cities.

Many countries and organizations are investigating the integration of GeoBIM. ESRI collaborated with experts from the Architecture, Engineering, and Construction industry to use BIM in building new workflows to strengthen the integration of GIS and BIM. Many countries including China, Japan, the Republic of Korea, and Singapore have published their respective strategic plan or support policies for BIM.

4. Data processing solutions

a. Artificial Intelligence (AI) and Machine Learning

Artificial Intelligence (AI), in particular image analysis and information extraction, is one of the biggest opportunities for advancement in the geospatial industry in the next decade. The development of such machine learning capabilities enabled its wide-range application in imagery and object recognition. With the large volumes of satellite imagery made available in the cloud, the technology can perform automatic labelling, change detection and feature extraction. Therefore, the speed and scale of doing those previously manual and time-consuming tasks can be improved.

Box 10 PulseSatellite

PulseSatellite,[a] is a collaborative web-based tool that combines cutting edge AI with human expertise to extract the most relevant information from satellite imagery for use in humanitarian contexts. Every day, millions of images are captured from space by an ever-growing number of satellites. In cases of humanitarian crises or in conflict areas, accurate and timely satellite image analysis is key to supporting critical operations on the ground. Such cases include monitoring population displacement, settlement mapping, damage assessment, flood assessment and identifying the direct impact of earthquakes, volcanoes, cyclones and landslides. Until recently, this type of analysis was done by human analysts who spent hours in front of a map manually counting and classifying structures and other elements. PulseSatellite will allow users to get the most out of earth imagery by employing artificial intelligence.[b]

Figure 9.6 PulseSatellite's roof segmentation model used for rapid slum mapping

Source: PulseSatellite
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

[a] Global Pulse, "PulseSatellite". Available at https://www.unglobalpulse.org/microsite/pulsesatellite/

[b] Felicia Vacarelu and Tomaz Logar, "PulseSatellite: A collaboration tool using human-AI interaction to analyse satellite imagery", Global Pulse, 10 February 2020. https://www.unglobalpulse.org/2020/02/pulsesatellite-a-collaboration-tool-using-human-ai-interaction-to-analyse-satellite-imagery/

Many current applications are being used in disaster risk response scenarios with the aim to provide timely, dynamic and accurate mapping solutions in preparation, response and recovery phase of disasters. There are also initiatives in progress, such as in the detection of all changes in the built and natural environment over the long-term, in the applications of computer vision techniques to speed up and improve the accuracy of mapping data generation and dissemination, thereby delivering timely maps for large geographic territories. However, these projects still face multiple challenges in tackling problems, which include volatility and the large-scale nature of some disasters. Furthermore, problems of interoperability, data privacy and reliability of cloud data storage exist as well.

Conclusion

Trends and innovative technologies implemented with geospatial technologies will play a large role in new and emerging solutions to sustainable development. The world has already seen major developments in ICT technology and services and these will continue to expand as such technologies become cheaper and more widely available. Integrating new technologies with geospatial data and applications provide additional tools and resources that countries around the region can utilise. Many of these examples and good practices have already been outlined within this Chapter. The development of satellite communications, such as additional GNSS navigation systems and Geospatial Data Sharing platforms, to name a few, will help countries move toward leveraging these technologies for data collection and integration. Big Data, AI, the IoT, crowdsourcing and machine learning are also being widely used and incorporated in more fields. Yet, in acknowledging that countries around the region are making steady progress toward innovation for sustainable development, we cannot ignore the digital divide that still exists within the region. Many countries still lack access to basic internet services and infrastructures posing challenges to digital development. Progress still needs to be made within some areas to ensure that all countries have access to basic digital technologies in order to move forward.

The "Space+" initiative, put forward by ESCAP, to address some of the above issues goes beyond the traditional space applications approaches to support the implementation of The Asia-Pacific Plan of Action on Space Applications for Sustainable Development (2018–2030) and incorporates the seven keys to success, as discussed above. It will seek to: (a) leverage frontier technologies such as AI, IoT, cloud computing and Big Data; (b) engage end users in multiple sectors, youth and the private sector; (c) more effectively manage information through the creation of a regional or national cloud-based metadata platform; and (d) strengthen implementation through enhanced partnership with global and regional stakeholders.

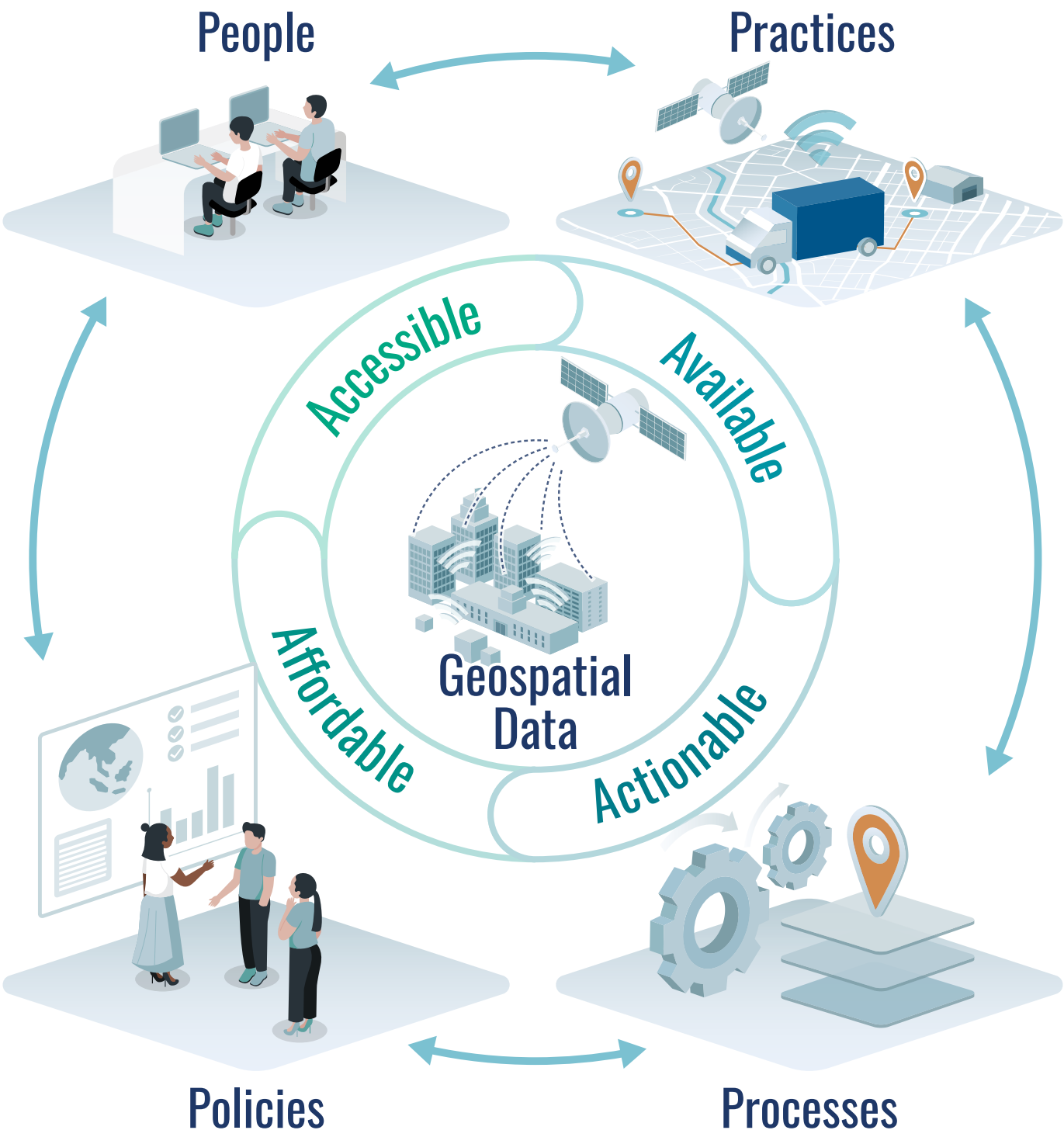
Chapter 10.

Key factors for success and recommendations

Through the numerous country practices discussed, it is hoped that this publication has helped readers understand the value and wide range of benefits that geospatial information provides to Member States of the Asia-Pacific region. This multi-sectoral and cross-cutting compilation and analysis of space applications serves to help nurture the integration of geospatial information applications into the planning and actions that are being taken toward achieving the Sustainable Development Goals (SDGs). Furthermore, it is hoped that such analysis promotes peer learning and innovative thinking. This final section advocates policies and gives recommendations for decision makers, while fostering intersectoral linkages and synergies.

Seven key factors for success emerge from the review and analysis of over 100 practices and examples contributed by countries and organizations in the Asia-Pacific region, during the start of Phase I of the implementation of The Asia-Pacific Plan of Action on Space Applications for Sustainable Development (2018-2022) (Plan of Action). These examples

Geospatial data should be accessible, available, actionable and affordable to benefit people and inform practices, processes and policies



demonstrate that fully leveraging geospatial information for development will not happen spontaneously, but rather will require well-designed and coordinated national and regional initiatives, policies, and openness to effect the desired changes.

The approach to reviewing and analysing the practices included the following: Examining the *practices* in the region, the *people* behind them and benefitting from them, the *processes* behind the implementation, and the subsequent or enabling *policy* elements. The *practices* provide evidence through specific cases, over a range of applications, and valuable lessons learned. The capability of *people* is critical for the effective implementation of policies, calling for an evaluation of well-trained professionals who made these practices possible, who were trained to provide future sustainability and are capable of implementing and understanding geospatial applications. Indeed, the *processes* behind the implementation of geospatial applications do not occur overnight, especially as they are based on individual country and community needs, bridge sectoral silos, and provide space for co-learning, thereby co-creating new ways of integrating, using and sharing information.

The exploration of geospatial information in the region revealed the importance of an enabling *policy* environment. This includes policies and strategies for data sharing and harmonized national data and statistics to support coordinated and evidence-based policy measures. Making geospatial data, tools and innovations *accessible, available, actionable* and *affordable* should be an important task for policymakers, together with the support of all stakeholders, including industry, academia and the private sector. Some of the countries in the Asia-Pacific region already have implemented ***relevant policies, strategies and plans*** that recognize and tap into the benefits of incorporating geospatial information into management, decision-making, and monitoring from which others can learn .[1] Overall, the examples showcase good practices from the region and the progress achieved toward the implementation of the Plan of Action.

Seven key factors for success

1. Invest in national experts

The rapid innovation in geospatial and space applications simultaneously provides a multitude of possibilities for sustainable development and considerable challenges for many countries, in terms of technical capacity-building, which is also the priority request by countries through the Plan of Action. To effectively and continuously harness cutting-edge geospatial technology applications, which often employ novel methods and explore unfamiliar territories, Member States should make plans for long-term capacity development that respond to local needs. The following recommendations aim to help Member States enhance their existing capacity-building practices.

- *Enhancing technical expertise through international and regional collaborations and partnership-building.* To help address the significant capacity gaps within the Asia-Pacific region, the Plan of Action calls for partnership and collaboration among Member States, United Nations agencies, intergovernmental mechanisms, and international and technical organizations. The learning of new and innovative space applications through partnership can take multiple forms, including but not limited to: dedicated training courses on specific, needs-driven topics, formal higher education, hands-on training or learning during co-development and implementation, and a constant follow-up of progress.
- *Prioritizing country ownership of tools for more appropriate customization towards local needs when co-developing.* To ensure space applications are human-centric, capacity-building partnerships should keep sight of local needs, goals and attributes when developing and implementing geospatial technologies. This process involves ***customizing local solutions*** by using systems and tools that are adaptable and accommodating to different country contexts.[2]
- *Building national capacity to operate and design geospatial applications sustainably.* Through capacity-building, countries should be able to internalize the understanding of both the front- and back-end of the tools and their functionalities. The resulting in-depth technical know-how can enable countries to sustain the functioning of applications. ***For example***, by first showing countries how to use space applications for a particular purpose, then leading them through the applications gradually and progressively, subsequently following up with technical support as needed, and finally seeing countries support other countries.[3] Examples of such capacity-building activities include doctoral fellowships and training approaches to train national focal points who can then train others in

[1] See examples in Table 2.1 in Chapter 2.

[2] See Regional Drought Mechanism example in Chapter 3

[3] See Mongolia drought monitoring case in Chapter 3

The following key factors were important to the implementation and effectiveness of the country practices reviewed in this publication. As countries work toward the implementation of the first phase of the Plan of Action, policymakers should consider these factors to best integrate geospatial information applications into their planning and actions towards achieving the SDGs. These key factors should be accompanied by good governance, including a clear vision, guidance, coordination within and across sectors, and participation of relevant stakeholders. This requires political commitment, institutions that are empowered to act for the public good, civil society participation and accountability. Each of the seven key success factors include more specific recommendations, which are based on the analysis of enabling elements for fully leveraging the potential of geospatial information in Asia and the Pacific:

Seven Key Factors for Success

to leverage geospatial information for sustainable development

accompanied by good governance

1. **Invest in cultivating national experts**
2. **Integrate geospatial data with other data sources**
3. **Use geospatial data for creating, implementing and monitoring policies**
4. **Incorporate geospatial information into national institutions and platforms**
5. **Ensure privacy, safety and ethics of data**
6. **Provide open data access**
7. **Collaborate on local to international levels**

their respective countries, ministries and agencies (training of trainers model).

- *Encouraging cooperation between stakeholders from public and private sectors to share private expertise for public good.* Geospatial applications often attend to cross-sectoral challenges and involve multiple stakeholders. A healthy dialogue engaging stakeholders can combine the natural strengths of all stakeholders, ensuring the effective use of time, human resources, and financial investments in technical capacity-building. Approaches, such as *incubators* for entrepreneurs leveraging space applications could encourage this cooperation and engage youth in the process as well.[4]
- *Developing and enhancing subregional cadres of experts and centres of excellence for geospatial information analysis*. Not all countries, especially the Pacific Small Island Developing States, can afford to engage full-time with an Earth observations (EO) expert, therefore developing a subregional cadre of experts should be considered. There are strong centres of excellence in the region, but improvements are necessary to build government capacity to ask questions, understand technology, and identify possibilities.[5]

2. Integrate geospatial data with other data sources

Sectors in all countries have a need for reliable geospatial information and EO for national development. They are critical components of the national infrastructure, serving as both a nation's blueprint of what happens where and as the means to integrate a wide variety of data so that Governments are able to ensure economic growth, social development sustainability, environmental sustainability and national prosperity. Existing and highlighted country practices demonstrate the importance of data integration from multiple sources and at multiple levels. They also give rise to challenges and opportunities in data integration, and therefore the following approaches are suggested:

- *Planning and investing in field campaigns (ground-truthing) data collection.* Such data is essential for calibration, validation, customizing systems and the subsequent processing of geospatial information to ensure high accuracy, reliability and relevance of outputs. Therefore, more investments in financial and human resources are suggested, especially in countries with Big Data gaps. Additionally, during the investment and developing stages of data collection, programmes should be designed to ensure that data is collected at appropriate intervals.
- *Integrating statistical information, ground-level, and space-based data.* Such an approach provides important evidence for cost-benefit and risk analysis inputs in order to support policy and planning. The growing trend of *integrating* ground and space data, crossover data, with georeferenced tags and statistical processing, will also be challenging for many developing countries in the Asia-Pacific region.[6]
- *Ensuring access to integrated information through a consistent data format, and integration of tools and application programming interfaces (APIs) to seamlessly present information and knowledge from multiple data formats to the user*. For example, advance warning information for agricultural lands can be provided in the form of bulletins in the same format and on a single platform to both decision makers and farmers and geospatial data sharing among users within the government across different departments. *Common access* to such information eases communication and facilitates rapid action, which is particularly important in early warning systems.[7]
- *Developing a framework for common usage of new sources of geospatial data between different countries, sectors or organizations*. In doing so, areas to be taken into consideration may include: regulations and ethics code for data storage, transmission and usage; cooperation to design common data formats, collection infrastructures, and data structures; sharing of findings; risk assessment and maximizing of benefits. For example, the ESCAP "OneData-OneMap-OnePlatform" initiative encourages Member States to build a system ('OnePlatform') that utilizes the frontier technologies and integrates with Big Earth Data ('OneMap') to support local SDGs monitoring and decision-making. Given the unstructured characteristics of Big Earth Data, common data format technologies for cross-sectoral geospatial data sharing can be implemented so that Big Earth Data can facilitate and support the SDG indicators. In this way, Member States and stakeholders will be able to explore the possibilities for effective country-level SDGs assessment and monitoring.

[4] See Philippines incubator programme and Japan's S-Booster programme in Chapter 2

[5] Andrew Steven and others, "An Earth observation platform to support Pacific Island Nations environmental, climate and livelihood needs - consultation workshop", Commonwealth Scientific and Industrial Research Organization, Final Report, 2019.

[6] See Australia's Data Cube and the Integrated Geospatial Information Framework examples in Chapter 9.

[7] See the Integrated Geospatial Information Framework section in Chapter 9.

3. Use geospatial data for creating, implementing and monitoring policies

Space-derived data and information plays a key role in evidence-based decision-making for the efficient management of assets, environment, and communities. Around 40 per cent of the Sustainable Development Goal targets rely on the use of geolocation and EO.[8] Table 10.1 provides an overview of country level examples from the Asia-Pacific region where geospatial data is needed or can support, together with statistics, the implementation of the SDGs. The graph in Figure 10.1 shows the total number of indicators per SDG where geospatial data can contribute.

Geospatial information can play an important role in global stewardship, enabling faster, more accurate and trustworthy information to be made available to inform decisions, monitor progress, and assess the impact of interventions.[9] However, such information alone cannot bring about improved management, decisions or change. It must follow a clear and reliable pathway to the users and be embedded in the appropriate fora or platforms for decision-making and policy dialogue. It must rely on a process that requires continuous engagement and effective communication that should be based on individual country and community needs, bridging sectoral

[8] A/AC/105/1230, see United Nations General Assembly, Committee on the Peaceful Uses of Outer Space, Sixty-third session, *Coordination of space-related activities within the United Nations system: directions and anticipated results for the period 2020-2021 – megatrends and the Sustainable Development Goals*, Report of the Secretary-General, 2020.

[9] Ibid.

Table 10.1 Country examples of geospatial data use for SDG indicators, from the Asia-Pacific region

Goal	Indicator	Country examples from the Asia Pacific region
Goal 6.	6.3.2 Proportion of bodies of water with good ambient water quality	**Algal Early Warning System, Australia.**[1] The Algal bloom early warning alert system uses EO data ingested from the Australia Geoscience Data Cube alongside traditional data and methods for water quality monitoring.
	6.5.1 Degree of integrated water resources management	**Flood Prediction System Using the Global Satellite Map of Precipitation (GSMaP) - Bangladesh, Pakistan, the Philippines and Viet Nam.**[2] Monitoring and warning systems have been implemented within the Asia-Pacific region using a combination of satellite-based global precipitation data (GSMap) with ground observations to improve the prediction accuracy of weather events. This can help mitigate flood damage and risk through improved predictions and early warning broadcasts. Flood prediction systems, using GSMaP, have been implemented in Bangladesh, Pakistan, the Phillippines, and Viet Nam.
	6.6.1 Change in the extent of water-related ecosystems over time	**Global Mangrove Watch, Japan.**[3] The Global Mangrove Watch is a global-scale dataset, and in 2019 was selected by the United Nations Environment Programme (UNEP) to be used as the official mangrove dataset for countries reporting on SDG Indicator 6.6.1. Datasets can be accessed via the SDG 6.6.1 online geospatial platform, which provides global data on freshwater ecosystems.[4]
Goal 9.	9.1.1 Proportion of the rural population who live within 2 km of an all-season road	**RuralAccess Index (RAI), Philippines.**[5] The Philippine Statistics Authority (PSA) has used the RAI, which measures the proportion of people who have access to an all-season road, within an approximate 2 km walking distance. This has been undertaken within the Davao Region using geospatial data and analysis. The PSA plans to compute the RAI for all provinces within the country.

Goal 14.	**14.1.1 (a) Index of coastal eutrophication; and (b) plastic debris density**	**Marine Park Management, Australia.**[6] The Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Bureau of Meteorology, in Australia, are using EO data from MODIS-Aqua to collect near real-time satellite data for testing the quality of marine water. These methods have been integrated into an online dashboard to show daily data on the quality of water, which is used by the Marine Park Authorities for monitoring and assessment of the Great Barrier Reef.[7]
Goal 15.	**15.1.1 Forest area as a proportion of total land area** **15.2.1 Progress towards sustainable forest management** **15.4.2 Mountain Green Cover Index**	15.1.1 and 15.2.1 **Mapping Forest Cover Extent and Change for Sustainable Forest Management - Bangladesh, Nepal and Viet Nam.**[8] Satellite-derived imagery, such as Landsat or Sentinel, is being generated and used within national-scale mapping and monitoring of forest resources at the global scale with the Global Forest Watch initiative providing data on the extent of loss of tree cover. Additional methods are being used to map the extent of forest cover and its change over a defined period, in order to establish reference data and aid land-use policies.[9] 15.1.1 and 15.4.2 **Mapping forest area, New Zealand.**[10] Sentinel-2 data is collected and used in New Zealand to form the basis of national land-use cover maps. This national mosaic is compared with previous maps to create change detection and classification maps and areas of forest are then derived from these land cover maps.

1 Group on Earth Observations (GEO), "Earth Observations in support of the 2030 Agenda for Sustainable Development", Japan Aerospace Exploration Agency (JAXA), March 2017, pp. 9 and 10. Available at https://www.earthobservations.org/documents/publications/201703_geo_eo_for_2030_agenda.pdf

2 Ibid., pp. 11 and 12.

3 Group on Earth Observations (GEO), "Country use case of EO use for SDG indicator". Available at https://eo4sdg.org/wp-content/uploads/2020/04/Japan_6.6.1.pdf

4 United Nations Environment Programme (UNEP), "SDG 6.6.1 Freshwater Ecosystems Explorer". Available at https://www.sdg661.app/

5 Mae Abigail O. Miralles and Joy Angiela H. Garraez, "Measuring the Rural Access Index (SDG 9.1.1) for the Philippines", Philippine Statistics Authority, International Seminar on the Use of Big Data for Official Statistics, Hangzhou, China, 16-18 October 2019. Available at https://unstats.un.org/bigdata/events/2019/hangzhou/presentations/day2/3.%20RAI%20Presentation%20for%20International%20Symposium_Philippines.pdf

6 Group on Earth Observations (GEO), "Earth Observations in support of the 2030 Agenda for Sustainable Development", Japan Aerospace Exploration Agency (JAXA), March 2017, pp. 21 and 22. Available at https://www.earthobservations.org/documents/publications/201703_geo_eo_for_2030_agenda.pdf

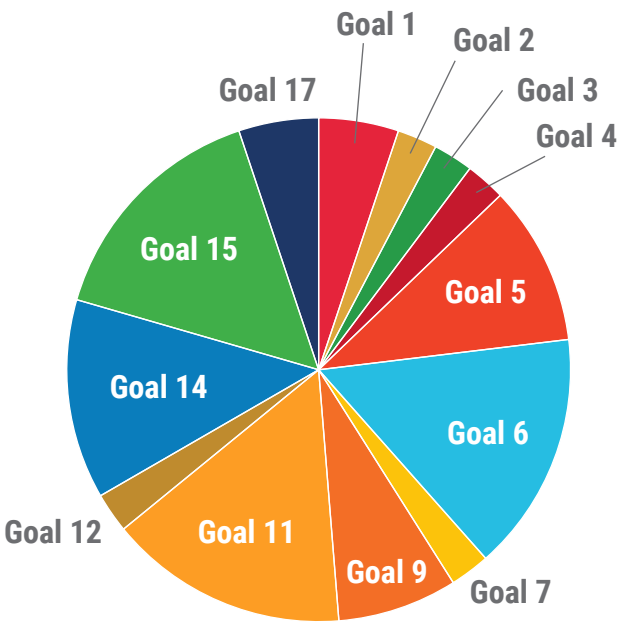
7 Australian Government, Bureau of Meteorology, "eReefs Marine Water Quality Dashboard". Available at http://www.bom.gov.au/marinewaterquality/

8 Group on Earth Observations (GEO), "Earth Observations in support of the 2030 Agenda for Sustainable Development", Japan Aerospace Exploration Agency (JAXA), March 2017, pp. 23 and 24. Available at https://www.earthobservations.org/documents/publications/201703_geo_eo_for_2030_agenda.pdf

9 Global Forest Watch Map. Available at https://www.globalforestwatch.org/map/?menu=t%3D

10 Group on Earth Observations (GEO), "Country use case of EO use for SDG indicator". Available at https://eo4sdg.org/wp-content/uploads/2020/04/NZ_15.11_15.4.2.pdf

Figure 10.1 Number of indicators per SDG where geospatial data can contribute



Source: UN-GGIM Available at https://ggim.un.org/meetings/2020/WG-GI-Mexico-City/documents/6.Jimena-Juarez.pdf
and GEO Available at https://www.earthobservations.org/documents/publications/201704_geo_unggim_4pager.pdf

silos, raising political awareness and providing space for co-learning. The following elements support the process of including geospatial information in decision-making and policy dialogue:

- *Regular engagement, including awareness events highlighting the usability and benefits of geospatial applications* by bringing together decision makers to inform them about the applicability, value and benefits of these tools and how they can be used effectively for decision-making purposes.[10]
- *Space applications offer powerful tools to support decision makers in prioritizing policies that are citizen-focused and provide clear benefits for citizens.*[11] In addition to identifying priorities for targeting investments, space applications can help support monitoring efforts and prioritizing policies that are geared towards maximizing human wellbeing. In doing so, space applications can become essential tools to track SDG progress.
- *Geospatial applications offer stakeholders, across multiple agencies, the option to create planning scenarios, analyse different site options, and assess impacts from a local to national level.* They also provide a space to collaborate and jointly assess planning options and inter-dependencies, thereby strengthening the planning process.[12]
- *Leveraging geospatial and digital tools for increased community engagement.* Many examples reveal the importance of engaging communities in dialogues around issues that affect them. Many of the emerging technologies provide easily accessible platforms that integrate information from the public as feedback to the decision makers.[13] Incorporating citizens' voices, at both the local and national level, *provides* the basis for monitoring systems and support.
- *Using geo-referenced and integrated data for urgent and necessary decision-making.* Countries that leveraged space applications for addressing the COVID-19 pandemic and had systems and processes in place for collecting, managing and disseminating information related to the pandemic, were ahead of the curve.[14] However, many developing nations continue to lack the infrastructure and trusted data to make evidence-based decisions.
- *Helping decision makers understand the full potential, limitations, and application of geospatial information.* Developing visualizations that include geospatial information, dashboards, and scenarios can support policymakers in understanding and managing the complexity of geospatial information and can provide the *necessary* data for expanding the government's ability to plan for a range of possible threats and stresses.[15] These are most effective when requested by specific ministries, agencies, or institutions to address specific problems.

4. Incorporate geospatial information into national institutions and platforms

With an emphasis on 'all countries' being able to measure and monitor development progress with good policy, science, technology and especially data, the SDGs are highly dependent on geospatial information. However, the provision of geospatial information and technologies to support the implementation of the SDGs has not yet been adequately applied and mainstreamed by countries, as they simply do not have the appropriate frameworks, guidance and methodologies to do so. To ensure that geospatial information continues to be included in decision-making processes and dialogues in a timely manner, countries should plan

[10] See drought examples in Chapter 3.

[11] See urban planning examples in Chapter 6.

[12] See Actionable Intelligence Policy example and urban planning examples in Chapter 6.

[13] See examples on citizen science in Chapter 9.

[14] See COVID-19 section in Chapter 6.

[15] See COVID dashboard examples in Chapter 6.

to institutionalize it through agencies, committees, working groups, and other official platforms. This removes the dependency upon specific projects or individuals, where the motivation and ability to continue is at risk of drying up with outside funding or changes of leadership. Just like Governments have built governance for other organizational functions, governance approaches that help treat data as a strategic asset, and are focused on adding value with data, are needed.[16] Through practical examples of how this has been accomplished by some Governments, along with the social and economic benefits, policymakers can clearly see how replicating or tailoring a particular application for their country can help support many areas of their development. For this reason, intergovernmental discussions and regional practices is one of the three implementation modalities of the Plan of Action, which is in part facilitated by the Regional Space Applications Program for Sustainable Development (RESAP).

- *Institutionalizing and mainstreaming the role of agencies that specialize in satellite-data based monitoring* in relevant working groups and committees helps formulate policy that is appropriate, timely and up to date.[17]
- *Building governance approaches* that treat data as a strategic asset with a focus on adding value for partners and beneficiaries enables integrative technologies, processes and tools, so that timely, reliable and quality information is delivered to citizens, businesses, organizations and governments. This is key for evidence-based decision-making and enhanced accountability of actions.
- *Integrating geospatial data into a nation's data strategy* while considering the data, people, and technology requirements for building a *sustainable environment* in which a country can function and develop efficiently.[18, 19] For example, Integrated Geospatial Information Framework (IGIF) provides a basis and a guide to develop, strengthen and integrate national geospatial information strategies, data, systems, tools, services and capabilities, to take practical actions to achieve digital transformation, and to bridge the geospatial digital divide in the implementation of national priorities and the 2030 Agenda for Sustainable Development.
- *Assigning officials with geospatial skills to institutions across sectors*. For example, the success of Geoscience Australia's COVID-19 contribution *is attributed to assigning* the digital mapping expert in the Department of Health the role of a Liaison Officer. This role was critical given how fast-paced the COVID-19 work had been, as it allowed for clear and concise lines of communication between the two agencies on what was needed and when.

5. Ensure privacy, safety and ethics of data

When integrating Big Data and other technologies into geospatial information usage, the key question of data privacy and security issues arise. This is because the technologies themselves have the capability to collect sensitive personal information and observe private property, new and evolving ways of data transmission and storage may have security issues, and when using third-party data, one may not be able to get informed consent from data providers.[20] To overcome these issues, the following measures may be taken:

- *Obtaining informed consent whenever possible and using second-level data with caution.* In other words, whenever the possibility to use personal data in the project is foreseen, informed consent should be gathered in advance, if feasible. Similarly, when using second-level data, one should examine the collection methods, context of collection, the information itself, and other aspects that may be associated with privacy and ethical issues.
- *Anonymizing and/or de-identifying data with personal information so that it cannot be traced back to individuals.* This is associated with first-hand data collection for projects and should be completed as soon and as thoroughly as possible, and throughout data collection, analysis and presentation of findings. Such procedures may include encrypting and anonymizing identifiable personal information, blurring geospatial images, or using the minimum (roughest) disaggregation scale for geospatial information possible, etc.

[16] United Nations, "Data Strategy of the Secretary-General for Action by Everyone, Everywhere with Insight, Impact and Integrity, 2020-2022". Available at https://www.un.org/en/content/datastrategy/images/pdf/UN_SG_Data-Strategy.pdf

[17] See agriculture examples from Thailand in Chapter 4 and COVID-19 examples in Chapter 6.

[18] United Nations, Statistics Division, Committee of Experts on Global Geospatial Information Management (UN-GGIM), "Future trends in geospatial information management". Available at https://ggim.un.org/future-trends/

[19] See Integrated Geospatial Information Framework section in Chapter 9.

[20] Gabrielle Berman, Sara de La Rosa and Tanya Accone, "Ethical Considerations When Using Geospatial Technologies for Evidence Generation", UNICEF, Office of Research-Innocenti Discussion Paper, June 2018. Available at https://www.unicef-irc.org/publications/pdf/DP%20 2018%2002.pdf

- *Devoting more technological effort to enhance data security and privacy in project design, data transmission, storage and usage.* Security issues are more complex for geospatial data, compared to common relational datasets. Therefore, extra measures (for example, geo-masking technologies) should be taken to prevent vandalization of data security in the data usage process.
- *Developing regulations and ethics codes for using frontier geospatial technologies.* As this is a relatively new area with ample novel approaches, common regulations for data safety and ethics are still under development, especially through international cooperation. The establishment of these regulations or codes are necessary for data safety and ethical usage.
- *Adhering to local legal considerations.* Existing regulations provide a good guideline when dealing with data safety and ethics issues. However, local or existing legal considerations should be regularly reviewed and updated as data science and geospatial technology advances.

6. Provide open data access

The benefits of open data are virtually endless and can be seen repeatedly. For example, once data is made open it is used widely and much of societal value (for example, freely available Landsat data) stems from the free and open data policy that allows users to access and reuse as much imagery as is necessary for their analysis, at no cost.[21] Storing open, analysis-ready data in the cloud, and ideally with consistent file formats can help meet the needs of end-users. One example of this is the Open Data Cube initiative, which seeks to provide an open source data architecture solution that provides value to its global users and increases the impact of EO satellite data, while simultaneously lowering the technical barriers for users to exploit the data to its full potential.[22] This aligns with the vision of a future where space-based data will be democratised. Hence, open data access for all relevant users will be helpful for gaining insights, enhancing impact and promoting cooperation. Efforts to enhance open satellite data collection and dissemination also supports the aim of making the benefits of space available to all States on a mutually agreeable and equitable basis, and encourages and coordinates space systems and data for collaborative observation, modelling and analysis.[23] The following aspects may be addressed in the process:

- *Providing open online information access for all relevant users, especially the public.* Access for relevant users to download information from monitoring systems in various formats (reports, maps, and GIS data layers) can enhance the impact of information and cooperation with experts from partner agencies. In addition, feedback from the public should be considered during the process, especially if they are the end users or if the information gathered relates to them.
- *Making use of cloud-based platforms.* These platforms are an excellent tool for open data access as they offer a unique opportunity to use and analyse geospatial information without investment in data storage and computational resources. However, a major challenge is that they do require training, buy-in, country-level data, customization and validation for more precise outputs. Integration of cloud-based platforms with projects using common data formats and structures (for example, the ESCAP-led 'OneData' project, and Open Data Cube (ODC) initiative) may be a promising solution for that.
- *Disseminating information and analytics outputs with media outlets and among government entities.* This can help maximize the benefits and impacts of geospatial information, especially when time is of essence and lives are at risk. This assumes the responsible and ethical use of the information (as discussed in Section 5 above).
- *Promoting data disaggregation by social inequities, needs, and vulnerabilities.* Increasing data disaggregation to address inequities in income, sex, gender, geography, age and disability etc., will help inform effective anti-poverty and inclusion policies to leave no one behind.[24] Such improved and more readily accessible geospatial data can also inform and shape policy decisions that can respond to other inequalities in areas such as environmental management, climate change adaptation, resilience building and disaster risk reduction, among many others. Disparities and inequities may only be

[21] Crista L. Straub, Stephen R. Koontz and John B. Loomis, "Economic Valuation of Landsat Imagery", U.S. Geological Survey, 2019. Available at https://pubs.usgs.gov/of/2019/1112/ofr20191112.pdf

[22] Open Data Cube, "An Open Source Geospatial Data & Analysis Platform". Available at https://www.opendatacube.org/

[23] A/AC/105/1230, see United Nations General Assembly, Committee on the Peaceful Uses of Outer Space, Sixty-third session, *Coordination of space-related activities within the United Nations system: directions and anticipated results for the period 2020-2021 – megatrends and the Sustainable Development Goals*, Report of the Secretary-General, 2020.

[24] OECD iLibrary, "Data and diagnostics to leave no one behind", in *Development Co-operation Report 2018: Joining forces to leave no one behind*" (Paris, OECD Publishing, 2018). Available at https://www.oecd-ilibrary.org/docserver/dcr-2018-10-en.pdf?expires=1597305993&id=id&accname=ocid195767&checksum=2CE38E79B48A4949651443BC301EFBD8)

eliminated if there is high-quality information to track immediate problems and their underlying social determinants, as well as to guide the design and application of specific development approaches. For example, integrating geospatial data with census or survey data is needed to produce spatially disaggregated population estimates, which can then be aggregated for national or administrative purposes.[25]

7. Collaborate across local and international levels

Given the breadth of thematic and sectoral areas where geospatial information and space applications can add value, there is a need for engagement across a broader set of line ministries and responsible authorities, beyond the traditional space applications sector, and even beyond borders. Enhanced regional cooperation facilitates the access of countries to timely satellite-derived geospatial data, expertise and resources, and provides inspiration through the sharing of knowledge and good practices. Partnerships are necessary to combine available data and expertise and maximize results. Important elements of collaboration include:

- *Enhancing international, inter-organizational and cross-industry cooperation by using frontier technologies*. Not all populations are, however, able to equally benefit from technical developments. While developed countries may be grappling with frontier technological developments, developing countries, the least developed (LDCs),[26] landlocked developing countries,[27] and the Pacific Small Island Developing States (SIDS),[28] are yet to fully benefit from existing technologies. Space-related activities of entities of the United Nations play a key role in addressing the interrelated technical, development and space divides.[29]

[25] Ibid.

[26] Least developed countries in the region include Afghanistan, Bangladesh, Bhutan, Cambodia, Kiribati, Lao People's Democratic Republic, Myanmar, Nepal, Solomon Islands, Timor-Leste, Tuvalu and Vanuatu.

[27] Landlocked developing countries in the region include Afghanistan, Armenia, Azerbaijan, Bhutan, Kazakhstan, Kyrgyzstan, Lao People's Democratic Republic, Mongolia, Nepal, Tajikistan, Turkmenistan and Uzbekistan.

[28] Small Island Developing States in the region, such as Fiji, Kiribati, Maldives, Marshall Islands, Micronesia (Federated States of), Nauru, Palau, Papua New Guinea, Samoa, Singapore, Solomon Islands, Timor-Leste, Tonga, Tuvalu and Vanuatu; Associate members – American Samoa, Cook Islands, French Polynesia, Guam, New Caledonia, Niue and Northern Mariana Islands.

[29] A/AC/105/1230, see United Nations General Assembly, Committee on the Peaceful Uses of Outer Space, Sixty-third session, *Coordination of space-related activities within the United Nations system: directions and anticipated results for the period 2020-2021 – megatrends and the Sustainable Development Goals*, Report of the Secretary-General, 2020.

- *Leveraging international collaboration to address the geospatial digital divide*, particularly access to data, tools and expertise. The gaps in the geospatial capacity of LDCs and the Pacific SIDS as compared with higher income economies can be extensive and can severely limit the ability of some countries to even access geospatial information for sustainable development. International collaboration can help. Fortunately, a range of new satellite capabilities, processing and analytical tools (for example, platforms like Data Cubes) and access (free access to EO archives and new telecommunication links to the Pacific Islands) will make it possible to deliver EO products and services that are useful to these communities (see Common Sensing project in Chapter 8).[30]
- *Improving cooperation among relevant agencies, from both public and private sectors,* for swift implementation. For most efficient and effective resource mobilization, especially in a time of crisis, it is important to combine the might of both public and private sectors to develop innovative solutions. For example, during the COVID-19 pandemic, a series of innovations involving geospatial technologies resulted from public-private partnerships. They have made significant contributions to the *control of COVID-19* in the Asia-Pacific region.[31]
- *Improving coordination between ministries involved in decision-making.* While the plans of individual countries, cities, and companies might show high levels of ambition, a lack of clarity on how to incorporate the plans into developmental programmes across various ministries could slow development. For example, through regional cooperation, ESCAP is co-developing a common data format and platform to capture, store, display, query, and analyse geospatial information and cross-sectoral statistical data simultaneously to support decision-making. International cooperation should not just involve those ministries with a mandate for space, but also the end user ministries.
- *Engaging communities to share* their inputs and priorities and to *better understand impacts and target beneficiaries of space applications*.[32] This includes ensuring that the voices of the youth and marginalized are heard as well. The integration of stakeholders, from different decision-making levels, in planning, negotiation and implementation is a key characteristic of sustainable development, and this requires a deep understanding of the processes at different scales. Geospatial information management tools can support this approach. There are huge opportunities for bringing geospatial data and tools closer to the end user, and for engaging locals for additional relevant data.
- *Capitalizing on the regional cooperation* that was highlighted as imperative in the Plan of Action. Regional cooperation has proven to be vital when disaster strikes,[33] during the COVID-19 pandemic, and will be crucial to building back better.

[30] Andrew Steven and others, "An Earth observation platform to support Pacific Island Nations environmental, climate and livelihood needs - consultation workshop", Commonwealth Scientific and Industrial Research Organization, Final Report, 2019. http://www.earthobservations.org/documents/geo16/eo_for_the_pacific_report.pdf

[31] See examples in the COVID-19 section in Chapter 6.

[32] See Odisha Land Title participatory mapping example in Chapter 6.

[33] See section 'An international call for support when disaster strikes' in Chapter 3.

Concluding remarks

Looking forward, we should consider new ways of reskilling young workers now to ensure they have the right abilities for the economy of the future, including investing in technology skills.[34] To help answer this call, ESCAP has designed the "Space+" initiative, which goes beyond the traditional space applications approaches to support the implementation of the Plan of Action and incorporate the seven keys to success, as discussed above. It will seek to: (a) leverage frontier technologies such as artificial intelligence (AI), Internet of Things (IoT), cloud computing and Big Data; (b) engage end users across multiple sectors, youth and the private sector; (c) more effectively manage information through the creation of a regional or national cloud-based metadata platform; and (d) strengthen implementation through enhanced partnership with global and regional stakeholders.

The COVID-19 pandemic has been a test not only of the preparedness plans for countries, but also to see how well geospatial information is integrated into local and national institutions, how easily and rapidly it can be accessed, and how well this system can provide timely evidence for decisions and subsequent monitoring. Additionally, the UN Secretary-General António Guterres has called on Governments to incorporate meaningful climate action in all aspects of recovery from the global pandemic.[35] Countries in the Asia-Pacific region have agreed to *strengthen regional cooperation to address the socioeconomic effects of pandemics* and crises,[36] which highlights the role and need for regional support for action against COVID-19, where geospatial information and relevant capacity-building will be vital in Leaving No One Behind.

[34] United Nations, "Rebirthing the global economy to deliver sustainable development – insights from young women economists on jobs and climate action", Secretary-General's opening video remarks, 3 September 2020. Available at https://www.un.org/sg/en/content/sg/statement/2020-09-03/secretary-generals-opening-video-remarks-rebirthing-the-global-economy-deliver-sustainable-development-insights-young-women-economists-jobs-and-climate-action

[35] UN News, "Make COVID recovery 'a true turning point' for people and planet, Guterres urges, calling for concerted action by G20", 3 September 2020. Available at https://news.un.org/en/story/2020/09/1071602

[36] ESCAP/RES/76/2; see *Resolution adopted by the Economic and Social Commission for Asia and the Pacific*, *Seventy-sixth session*, 21 May 2020. Available at https://www.unescap.org/commission/76/document/RES_76_2_ENG.pdf

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ANNEX Country practices for each Thematic Area

Chapter	Sub Section	Practices Number	Country	Practices Title
Disaster Risk Reduction – Chapter 3	Innovation in disaster preparedness and management	a	India	Uttarakhand, India: Uttarakhand, India: Big Data and disaster risk management
		b	Philippines	A multi-agency initiative for disaster risk information: GeoRiskPH
		c	Australia	Bushfire safety applications
	Disaster assessment and emergency response	a		Satellite data and information for disaster risk
		b	India	India: Early detection of the severe cylonic strom Fani, 2019
		c	The Islamic Republic of Iran	High resolution satellite images for flood responses
		d	Bangladesh	Extended flood area mapping system
		e	Kingdom of Tonga	Initial damage disaster report for tropical cyclone Harold
		g	Pakistan	Specialized Space Application Center for Response in Emergency and Disasters
		h	The Russian Federation	Co-deployment for risk monitoring: Cospas-Sarsat
	An international call for support when disaster strikes	a	India, Bangladesh, Republic of Korea	International Charter to assist in cyclone 'Fani'
		b	Indonesia, Japan,	Flood and landslides with imagery assistance
	Agroecosystem resilience: preparing for drought	Box 3		Earth observation data for drought resilience-building in South-East Asia
		a	India, China, Thailand, Cambodia, Kyrgyzstan, Mongolia, Myanmar, Sri Lanka	Regional Drought Mechanism
		b	China, Mongolia	China's support to Mongolia under the Regional Drought Mechanism
		c	India, Sri Lanka	India's Regional Drought Mechanism service node that supports drought monitoring in Sri Lanka
		d	Thailand	Drought monitoring in Thailand using space technology and geo-informatics
		Box 4	Viet Nam, Cambodia	Regional Drought and Crop Yield Information System

Natural Resource Management – Chapter 4	Agricultural monitoring and planning	a	Japan	Asia-Pacific Regional Space Agency Forum Space Application for Environment activity (SAFE)
		b	Bangladesh	Satellite imagery and data to support the agricultural sector
		c	Thailand	Managing agricultural areas through space applications and GISTDA initiatives
		Box 1	Cambodia	CropWatch Cloud brings universal access and easy-to-use templates
		e	Malaysia	Precision agriculture
	Water management	a	Australia	Monitoring water in the Great Artesian Basin
		b	Philippines	Hydrologic Dataset using LIDAR surveys
		c	Australia	Data Cube
		d	India	Water resource information system
	Marine and coastal management	a	Australia, India, Thailand	Coral reefs monitoring
		b	Philippines	Seagrass mapping and monitoring
		c	India, Bangladesh	Mangrove monitoring and conservation
		e	Japan	Fisheries resource management
	Land use management	a	India	Land use mapping through Bhuvan web portal
		b	Vanuatu	Ecosystem services within the Pacific Islands
Connectivity – Chapter 5	Access to telecommunication services	a	Myanmar	Surge in satellite-enabled telecommunication services
	Transport management and traffic navigation	a	Philippines	Use of frontier technologies to address road traffic incidents: LocalSim
		b	Hong Kong, China, Indonesia	Crash hot zone analysis
		c	Sri Lanka	Vessel traffic management system
		d	India	Use of geospatial technologies in transport management and traffic navigation
	Urban and territorial planning	a	Singapore	Integrated urban planning
		b	Australia	3D sustainable growth model
	Smart City	a	The Republic of Korea	Ubiquitous-City (U-City) technology leveraged during the COVID-19 pandemic

Social Development – Chapter 6	Social development in urban planning	a		The Atlas of Urban Expansion
		b	India	Odisha land title
	Health management: Monitoring, responding to and preparing for COVID-19	a	Thailand	Lockdown measure impacts and COVID-19 iMAP dashboard
		b	Indonesia	Heatmaps of vulnerability levels
		c	India	Bhuvan-COVID-19
		d	Fiji	Dashboard and managing disasters during COVID-19
		e	Malaysia	WebGIS Dashboard
		f	China	Health QR codes
		g	Philippines	Campaign supports innovative apps
		h	The Republic of Korea	Private sector's role in developing vital platforms
	Contamination and pollution	a	The Republic of Korea	Geostationary Environment Monitoring Spectrometer (GEMS)
		b	Thailand	Space and geospatial information for air pollution monitoring
		c	Viet Nam	Pollution and contaminated sites assessment
	Knowledge aggregation and evidence building	a		The 'Know Your City' Initiative
		c	Nepal	Heritage mapping and modelling
		d	China	Local monitoring of sustainable development in Deqing County
		e	The Russian Federation	Space education value chain
		f	Thailand	Actionable Intelligence Policy (AIP)
Energy – Chapter 7	Renewable energy infrastructure site appraisal	a		IRENA Global Atlas for Renewable Energy
		b	India, Sri Lanka and Philippines	Solar site selection using geospatial information
	Open-access information platforms	a		The Global Electrification Platform
		b		Monitoring rural electrification from space
		c		Asia-Pacific Energy Portal
		d	The Russian Federation	Digital Earth Project and Sputnik GIS product line for energy

Climate Change – Chapter 8	Climate modelling and projections	a	Philippines	High resolution climate change projections and regional climate simulations for improved climate information
		c	Malaysia	Big Data Analytics Proof-of-Concepts project (BDA-POC) for climate impact modelling and mapping
		d	Sri Lanka	Estimating the impact of climate change on agriculture
	Vulnerability and risk mapping	a	Sri Lanka	Mapping the impact of climate change on water resources and agriculture
		b	South Asia	Mapping multiple climate hazards
	Greenhouse gas, carbon and environmental monitoring	a	China	TanSat mission to promote global carbon monitoring
	Collaboration to build capacity towards climate resilience	a	Fiji, Solomon Islands, Vanuatu	International collaboration: Innovative international CommonSensing project
		b	Armenia	Modernization of hydrometeorological service
		c	Pacific Islands	The Pacific Islands Regional Climate Center and Pacific Climate Change Portal
Trends and Innovative Technologies – Chapter 9	Satellite communications: Background and trends	a		SpaceX Starlink and large small-satellite constellations
		a	Japan	Quazi-Zenith Satellite System (QZSS)
	Geospatial data sharing and integration technologies	Box 1	China	Fupin Cloud
		Box 2	The Republic of Korea	Smart Complaint System
	Data management and frameworks	Box 3	The Russian Federation	National Spatial Data Infrastructure (NSDI)
		Box 4	Philippines	Geoportal – One Nation One Map
		Box 5	Kingdom of Tonga	National Action Plan
	Data processing solutions	Box 6		PulseSatellite

For further information on this publication, please address your enquiries to:

Space Applications Section (SAS)

Information and Communications Technology and Disaster Risk Reduction Division (IDD)
United Nations Economic and Social Commission for Asia and the Pacific (ESCAP)
United Nations Building, Rajdamnern Nok Avenue, Bangkok 10200, Thailand

Email: escap-sas@un.org

Geospatial information has been providing far-reaching solutions to the pressing issues facing humanity, ranging from health, education, food security, agriculture, to disaster risk reduction and resilience-building. This compendium demonstrates the diverse use for geospatial information and applications and the vital role that they will continue to play in the future. This compendium has been designed and devised for policy and decision makers working towards sustainable development, as it shows clear linkages to both economic and social value. It showcases the benefits and importance of accessible, available, actionable and affordable geospatial data, tools and innovations to maximize its potential benefits to Member States of the Asia-Pacific region. It achieves this by highlighting relevant country situations and circumstances from across the region; these good practice examples cover the six priority areas identified in the Asia-Pacific plan of Action on Space Applications for Sustainable Development (2018-2030), including 1) disaster risk management; 2) natural resource management; 3) connectivity; 4) social development; 5) energy, and 6) climate change.

This is the first time such country-based practices are available in one place, in an interactive, searchable digital publication. This multi-sectoral and cross-cutting compilation and analysis of country-based practices helps assess implementation of the Plan of Action, while hopefully promoting peer learning and innovative thinking. As underlined in the Data Strategy of the UN Secretary General, data has become a strategic asset. Towards this end, ESCAP will continue to play a convening, knowledge exchange, and policy advising role in the implementation of the Plan of Action and for COVID-19 geospatial data-driven responses.

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