Geospatial Practices for Sustainable Development in South-East Asia 2022: A Compendium

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Geospatial Practices for Sustainable Development in South-East Asia 2022: A Compendium

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FOREWORD

The depth and range of geospatial practices featured in this Compendium are proof of the steady progress that countries in South-East Asia are making to advance the implementation of the Sustainable Development Goals (SDGs). This Compendium features their achievements under the Plan of Action on Space Applications for Sustainable Development in Asia and the Pacific (2018–2030) whose priority thematic areas are fully aligned with the regional priorities to achieve the SDGs.

Alongside well-established space applications in drought prediction and monitoring, we see emerging applications of space science and technology that improve the spatial mapping of poverty incidence; increase the availability and accessibility of air pollution data; accuracy and tracking of greenhouse gas emissions; and enable evidence-based accounting of land and other natural resources. In the context of the ongoing effort to manage the COVID-19 pandemic, geospatial information proved useful in understanding, tracking, and targeting the response to the epidemiological aspect of the pandemic, as well as its socio-economic impacts.

The demand for knowledge-sharing, technical support and expert training remains consistently high for many member countries to make geospatial information and space applications available, accessible, affordable, and actionable. Regional cooperation within ESCAP can help countries in responding to these demands as many examples in this Compendium show. The regional cooperation enabled by the Plan of Action can significantly facilitate sharing and access to satellite imagery and other required data, technical expertise, and resources. Countries in Asia and the Pacific appreciate the results delivered during the first phase of implementation of the Plan of Action and commit to strengthen their collaboration for scaled-up contributions of space applications and geospatial information to sustainable development.

The guiding theme for accelerating progress in implementing the Phase II of the Plan of Action has converged around "Space+ for our Earth and future" which comprises four components, namely (a) leveraging innovative digital applications; (b) engaging end users, including the private sector and youth; (c) managing data and information more effectively; and (d) enhancing partnerships with national, regional and global stakeholders.

As Ministers and Heads of Space Agencies convene at the Fourth Ministerial Conference on Space Applications for Sustainable Development in Jakarta, we hope that this Compendium will contribute to recognising the achievements of countries, facilitate the exchange of knowledge and replication of good practices across the region, while also providing a direction in further strengthening regional cooperation to further accelerate the Phase II of implementing the Plan of Action . We also hope that the achievements and innovations of countries featured in this Compendium will inspire and increase the involvement of young people in the space sector.

Armida Salsiah Alisjahbana

Under-Secretary-General
of the United Nations and
Executive Secretary of ESCAP

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This report benefited from the guidance of the members of the Intergovernmental Consultative Committee (ICC) on the Regional Space Applications Programme (RESAP) who reviewed the Compendium in various stages of its development at its twenty-fifth and twenty-sixth session in 2021 and 2022 respectively.

Under the guidance of Keran Wang, Chief of the Space Applications Section, IDD, Kareff Rafisura led the preparation and writing team. Members of the core drafting team consisted of Hamid Mehmood, Chul Min Lee, Ayeisha Sheldon, Armita Behboodi, and Rhys Newman Persoon. Patricia Budiyanto managed the collection of inputs from ICC members.

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The manuscript was edited by Anoushka Ali. The graphic design and layout were created by Jeff Williams.

This Compendium may be used in conjunction with the *Online database of geospatial practices and dashboard for reporting on the implementation of the Asia-Pacific Plan of Action on Space Applications for Sustainable Development (2018-2030)*, which serves as a living repository of regional and national activities implemented during Phase I of the Plan of Action. Submissions received from non-South-East Asian members and associate members are uploaded to this database.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF BOXES

ACRONYMS

AAL	Average Annual Loss
ADPC	Asian Disaster Preparedness Centre
AI	Artificial Intelligence
AIT	Asian Institute of Technology
APRSAF	Asia-Pacific Regional Space Agency Forum
ARTSA	ASEAN Research and Training Center for Space Technology and Applications
ASEAN	Association of Southeast Asian Nations
ASIS	Agricultural Stress Index System
AVHRR	Advanced Very High Resolution Radiometer
BRIN	Badan Riset dan Inovasi Nasional (National Research and Innovation, Indonesia
CRISP	Centre for Remote Imaging, Sensing and Processing (Singapore)
DICT	Department of Information and Communications Technology (Philippines)
DOF	Department of Fisheries (Thailand)
DOST	Department of Science and Technology (Philippines)
EDB	Economic Development Board (Singapore)
ESCAP	Economic and Social Commission for Asia and the Pacific
FAO	Food and Agricultural Organization
FIO	Forest Industry Organization of Thailand
GEE	Google Earth Engine
GEMS	Geostationary Environment Monitoring Spectrometer
GHG	Greenhouse Gas
GIS	Geographic Information System
GISTDA	Geo-Informatics and Space Technology Development Agency (Thailand)
GNSS	Global Navigation Satellite System
GovTech	Government Technology Agency (Singapore)
GPS	Global Positioning Systems
HADR	Humanitarian Assistance and Disaster Relief
ESV	Essential Climate Variable
ICC	Intergovernmental Consultative Committee of the ESCAP Regional Space Applications Programme
INASA	Indonesian Space Agency Secretariat
IoT	Internet of Things
IPCC	Intergovernmental Panel on Climate Change
IT	Information Technology
LTA	Singapore Land Transport Authority
MOAC	Ministry of Agricultural and Cooperatives of Thailand
MODIS	Moderate Resolution Imaging Spectroradiometer

MoE	Ministry of Environment (Cambodia)
MSMEs	Micro-, small-, and medium-sized enterprises
MULA	The Multispectral Unit for Land Assessment (Philippines)
NASA	National Aeronautics and Space Administration (USA)
NDVI	Normalized difference vegetation index
NERI	NUS Environment Research Institute (Singapore)
NESDC	The National Economic and Social Development of Thailand
NOAA	The National Oceanic and Atmospheric Administration (USA)
NTU	The Nanyang Technological University
OR PA	Research Organization of Aeronautics and Space
OSTIn	Office for Space Technology & Industry (Singapore)
PAPGAPI	The Pan-Asia Partnership for Geospatial Air Pollution Information
PDC	Pacific Disaster Center
PhilSA	Philippine Space Agency
PRISM	Platform for Real-Time Impact and Situation Monitoring
RESAP	Regional Space Applications Programme for Sustainable Development
REZoning	The Renewable Energy Zoning Tool
SaaS	Software as a service
SAR	Synthetic Aperture Radar
SCOSA	Sub-Committee on Space Technology and Applications
SDG	Sustainable Development Goals
SireNT	Singapore Satellite Positioning Reference Network
SLA	Singapore Land Authority
SPP	Small Power Producers
STDP	Space Technology Development Programme
SWCorp	Solid Waste and Public Cleansing Management Corporation
UAV	Uncrewed aerial vehicles
UNOSAT	United Nations Satellite Centre of UNITAR
USAID	United States Agency for International Development
VCDRM	Virtual Constellation for Disaster Risk Management
VDMA	Viet Nam Disaster Monitoring Authority
VHI	Vegetation Health Index
VITO	The Flemish Institute for Technological
VLEO	Very low Earth orbit
VMS	Vessel Monitoring System
VNDMA	Viet Nam Natural Disaster Monitoring System
WRF	Weather Research and Forecasting

Geospatial Practices for Sustainable Development in South-East Asia 2022: A Compendium

Chapter 1

The context of space applications for sustainable development in South-East Asia

This Compendium features examples of space applications in the public sector, which are spearheaded by space agencies, national sectoral agencies, development agencies, academic, and public organizations. Altogether, the examples show that despite capacity gaps and other constraints, countries have been actively developing and deploying integrated geospatial information in a wide range of socioeconomic sectoral applications. There has been a marked increase in the number and diversity of these applications since ESCAP began tracking them in 2019, a year after member States adopted the Plan of Action on Space Applications for Sustainable Development in Asia and the Pacific (2018–2030) (Plan of Action). The applications span a wide range of areas, such as disaster risk reduction, management, and response, crop monitoring, poverty mapping, land accounting, and ocean and air pollution monitoring. As Chapter 2 will show, space and geospatial information applications have played an essential role in providing spatial and temporal information to inform real-life situations, such as the management response to the COVID-19 pandemic, both with respect to its epidemiology and socioeconomic impacts.

Recent developments in the use of geospatial applications, at the policy and strategic level, convey the importance that countries have accorded to strengthening their capacities to capture the socioeconomic benefits of space science, technology, and its applications. For example, Indonesia, the Philippines, Singapore, and Thailand have all begun strengthening their capacity to capture the socioeconomic benefits of space applications through institutional and policy developments and reforms. While technological development is important, these initiatives have remarkable and very strong user-orientation development objectives (Box 1).

The Plan of Action adopted by ESCAP member States at the Third Ministerial Conference on Space Applications for Sustainable Development held in 2018, has been serving as a blueprint for the Asia-Pacific region to harness space and geospatial applications, as well as digital innovations to support countries in achieving the 2030 Agenda for Sustainable Development. The emphasis is to ensure that all countries, particularly those with special needs, benefit from space applications in achieving the Sustainable Development Goals (SDGs). The Plan of Action comprises 188 actions to make geospatial data and enabling technologies accessible, affordable, available and actionable in six priority thematic areas: (a) disaster risk reduction and resilience; (b) management of natural resources; (c) connectivity for the 2030 Agenda for Sustainable Development; (d) social development; (e) energy; and (f) climate change. The Plan of Action has just completed Phase I (2018-2022). In the ASEAN context, cooperation is facilitated by the Sub-Committee on Space Technology and Applications (SCOSA).[1]

Development context

As member States gear up to implement Phase II of the Plan of Action (2022-2026), their efforts are taking place against the backdrop of insufficient progress in the region towards the achievement of the SDGs.

Box 1.1: Recent policy and institutional reforms in South-East Asia to strengthen space science, technology and its applications

Singapore

The Office for Space Technology & Industry (OSTIn), Singapore[a]

In April 2020, OSTIn took on the mandate of being Singapore's national space office. The Singapore Economic Development Board (EDB) established OSTIn in 2013 to capture economic opportunities in the space sector. In its early years, OSTIn focused on growing a globally competitive space industry in Singapore, collaborating closely with local and international space industry players to realize their business and innovation initiatives, as well as with partners within and beyond Singapore's space ecosystem, to build up local research capabilities.

OSTin's S$ 150 million flagship Space Technology Development Programme (STDP) seeks to develop space capabilities to support domains, such as aviation, maritime, and sustainability, which are critical to Singapore and many other countries, as well as disruptive space technologies that can improve the competitiveness of the country's space industry.

Projects supported by the STDP include:
- Very low Earth orbit (VLEO) satellite technologies that would allow satellites to operate in orbits closer to Earth and deliver differentiated capabilities;
- Quantum key distribution (QKD) satellite solutions that would enable quantum-safe transmission of secure information; and
- Use of satellite data for applications, such as carbon measurement, reporting, and verification, agriculture, pollution monitoring.

The Philippines

The Philippine Space Act, signed into law in August 2019, created the Philippine Space Agency or PhilSA. It serves as the central government agency addressing all national issues and activities related to space. The law provides a framework for the Philippine Space Policy that will enable the country to become a truly space-capable and space-faring nation, specifically identifying six key development areas for this purpose. These include: National Security and Development; Hazard Management and Climate Studies; Space Research and Development; Space Industry Capacity Building; Space Education and Awareness; and International Cooperation.[b]

Indonesia

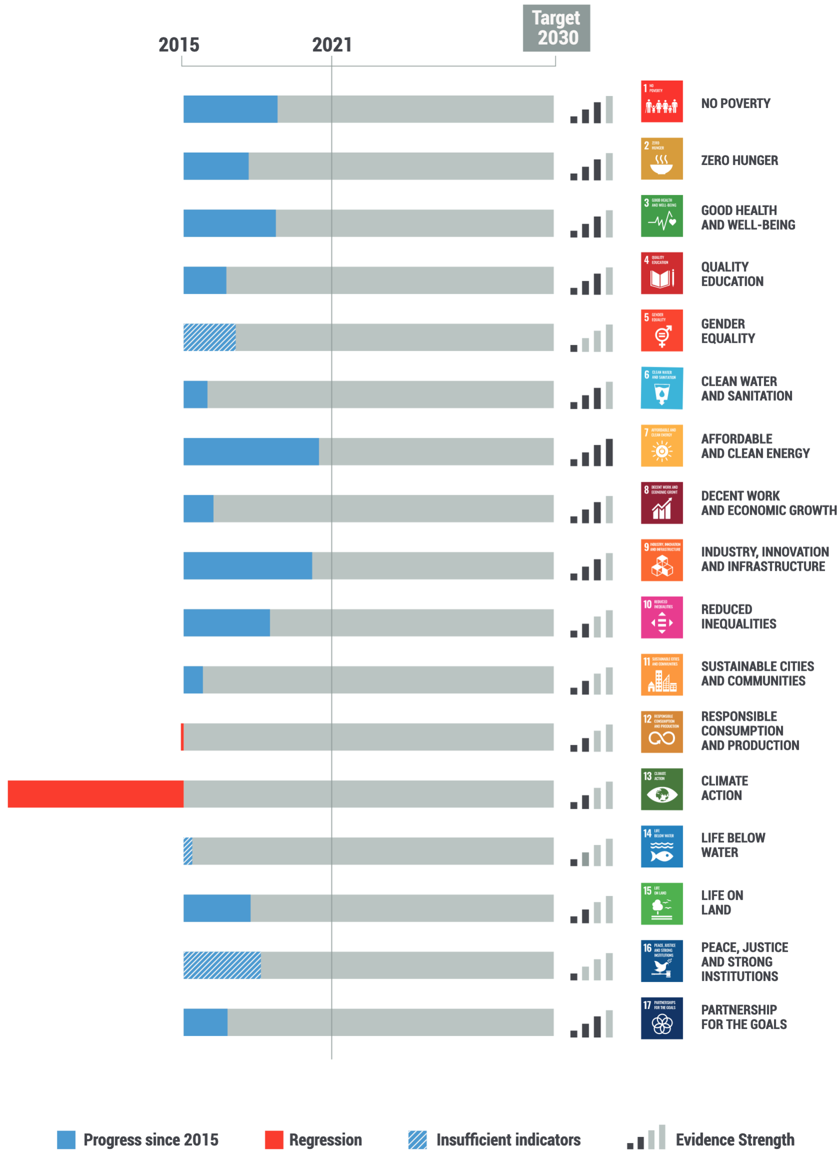
Based on Presidential Decree No.78/2021, the mandate for space agency (under Law No.21/2013 on Space Activities) is currently held by the National Research and Innovation Agency (BRIN). BRIN has set up the aerospace research, which is conducted by Research Organization of Aeronautics and Space (OR PA), while space diplomacy is conducted by the Secretariat of Indonesian Space Agency (INASA). Previously, the Indonesian National Focal Point for space activities was under the National Institutes of Aeronautics and Space (LAPAN), which is now being continued and strengthened under BRIN. INASA is responsible for handling international space affairs, including being a focal point for the activities of ESCAP. Another concrete example of the development of economic digitization is where 19 million micro-, small- and medium-sized enterprises (MSMEs) have entered the digital ecosystem, with a target to reach 30 million MSMEs, in 2024.[c]

Thailand

Thailand is drafting its National Space Master Plan (NSMP) to capture the opportunities offered by the new space economy for promoting socioeconomic development and national security. The NSMP is anchored in five key strategies. First, Thailand will invest in space infrastructure. It is envisaged that investments can come from government enterprises or from joint partnerships with the private sector. Second, Thailand will expedite space innovation research and development for commercial use and support high-level space education and educational institutions. Third, Thailand will develop human capital to pursue advanced space missions through investments in space education. Fourth, international collaboration is recognized as essential in space economic development. Finally, a more active private sector involvement in space research and development is envisaged which will be achieved through reforms in laws and regulations to facilitate investments in the new space economy.[d]

a. Contributed by The Office for Space Technology & Industry (OSTIn), Singapore, via email to the ESCAP secretariat, 6 October 2022.
b. Philippine Space Agency (PhilSA), "Philippine National Statement on Agenda Item 1(e) on the Progress in Implementing the Asia-Pacific Plan of Action on Space Applications for Sustainable Development (2018-2030), 25th session of the Intergovernmental Consultative Committee (ICC-25) on the Regional Space Applications Programme for Sustainable Development (RESAP), 24 August 2021, Bangkok, Thailand. Available at https://www.unescap.org/sites/default/d8files/event-documents/3.%20Philippines_PhilSA_Gay%20Jane%20P.%20Perez_Statement%20and%20Presentation.pdf
c. Secretariat of Indonesian Space Agency, National Research and Innovation Agency of the Republic of Indonesia, "Agenda item 2: Progress in Implementing the Asia-Pacific Plan of Action on Space Applications for Sustainable Development (2018-2030), 26th session of the Intergovernmental Consultative Committee (ICC-25) on the Regional Space Applications Programme for Sustainable Development (RESAP), 18 August 2022, Jakarta, Indonesia. Available at https://www.unescap.org/sites/default/d8files/event-documents/Indonesia%20.pdf
d. Contributed by GISTDA, Thailand, via email to the ESCAP secretariat, May 2022.

Figure 1.1: SDG progress in South-East Asia



Source: *Asia and the Pacific SDG Progress Report 2022: Widening disparities amid COVID-19* (United Nations publication, 2022a).

While recognizing that progress varies across countries, South-East Asia as a whole is not on track to achieve any of the 17 Goals by 2030, given the current pace of progress by countries in the subregion. Some progress has been made towards no poverty (Goal 1), but further progress is hindered by high social and economic losses due to disasters. Some progress is also seen in industry, innovation and infrastructure (Goal 9), and life on land (Goal 15). Areas indicating lack of progress are quality education (Goal 4), decent work and economic growth (Goal 8), and partnership for the goals (Goal 17). There are concerns about regression on clean water and sanitation (Goal 6), sustainable cities and communities (Goal 11), responsible consumption and production (Goal 12), climate action (Goal 13) and life below water (Goal 14).

Space and geospatial information applications are a critical part of the tools needed by decision makers and policymakers to develop and execute evidence-based policies, and make decisions to address the multidimensional challenges that are undermining progress in achieving the Goals. The Plan of Action is relevant, now more than ever, to the efforts of governments to accelerate progress towards the achievement of the SDGs. Notably, SDG actions in all priority areas of the Plan of Action need to be accelerated.

Table 1.1: Examples of how the Plan of Action can contribute to accelerating progress on selected SDGs

Reasons for regression or lack of progress in certain SDGs in South-East Asia[2]	Relevant priority theme in the Plan of Action	Examples of how space applications can help accelerate progress
Goal 1 (No poverty): High human and economic losses due to disasters.	Disaster Risk Reduction and Resilience	Geospatial and satellite data can be an innovative tool in disaster preparedness, risk reduction and emergency response; reducing both economic and social losses (UNOSAT[3] and Viet Nam[4]). In addition, geospatial data can supplement census data to map spatial distribution of poverty and guide development and targeting of poverty programmes (Indonesia[5] and Thailand[6]).
Goal 11 (Sustainable Cities and Communities): Road traffic deaths and human and economic loss from disasters	Connectivity for the 2030 Agenda for Sustainable Development	Satellite-derived data in conjunction with data from road emergency stations are used to map road traffic accident hotspots, observe traffic conditions and analyse driving behaviour, (Singapore[7] and Cambodia[8]). Geospatial 3D data models and applications can also combine cross-sectorial data to model and predict different scenarios, from road traffic management to disaster modelling within urban environments (Singapore[9]).
Goal 12 (Responsible consumption and production): Regression in improving efficiency in use of natural resources	Management of natural resources	Geospatial and satellite data, combined with ground sensors and meta data from a range of data sources, are used to monitor land use changes, forest management, water resource management, marine ecosystems and sustainable fisheries. Several of these examples are outlined in Chapter 2. Namely, geospatial data is being used to detect ocean-bound plastic pollution and consequently identify pollution hotspots. The resulting information is used to develop strategic action plans to develop strategies and prioritize investments accordingly. (Indonesia, Malaysia, Thailand and Viet Nam[10]).
Goal 13 (Climate action): Increased GHG emissions	Climate change	Data from newly-launched satellites that contain sensors can be used to improve accuracy and tracking of GHG emissions and their sources (Regional Asia[11]). Countries can also include innovative digital technologies, such as geospatial data, in national plans and policies for addressing climate actions, specifically reducing GHGs (Thailand[12]).

Space agencies and their user communities recognize the need to transcend traditional space applications to be able to address the complex societal challenges that undermine the achievement of the SDGs. In this regard, advances in digital technologies provide opportunities to speed up, augment and add value to traditional applications of location-based data. Subsequent chapters (Chapters 2 and 3) demonstrate how space and geospatial information applications could improve the design, implementation, and monitoring of initiatives and hence, improve outcomes in these areas.

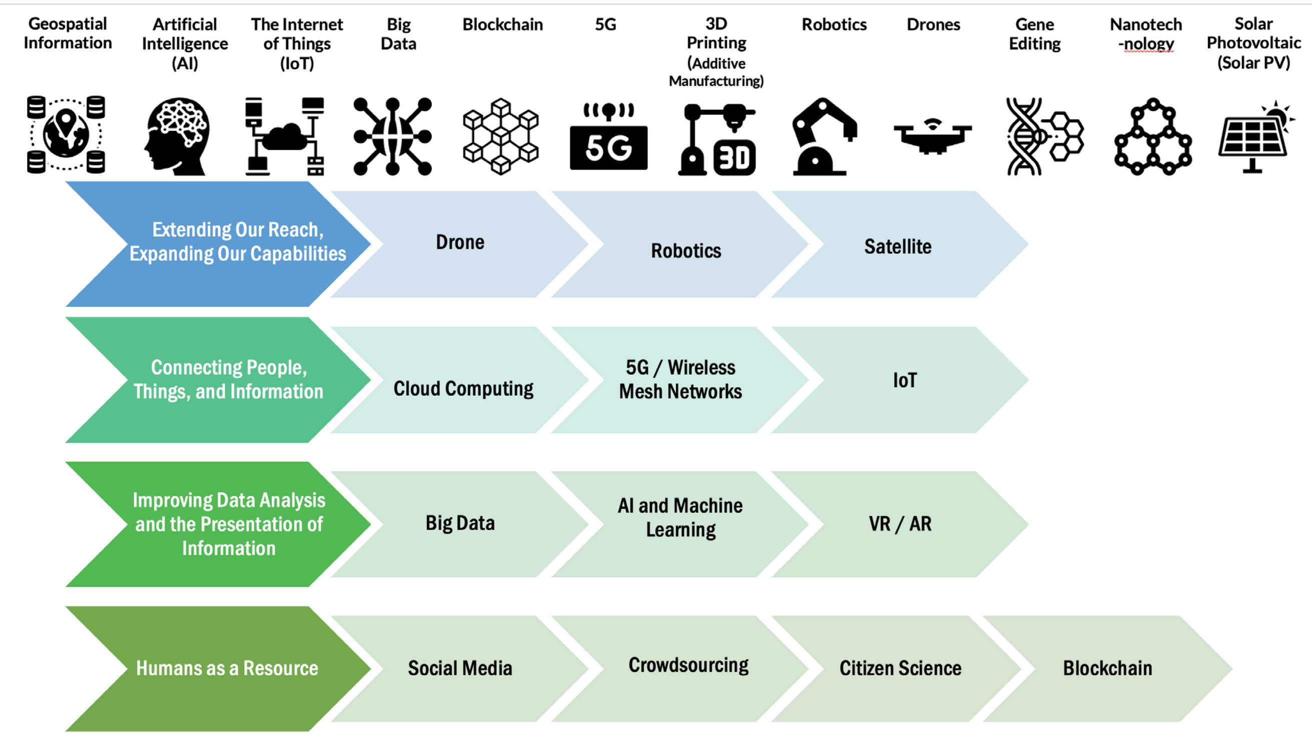
Technological context

Digital innovations have been transforming the way space-based data is managed, stored and integrated with data from the ground and other diverse sources, including smartphones, the Internet of Things (IoT) devices and drones. These innovative digital applications have improved the quality and granularity of data and have transformed how the resulting information and analytics are delivered to and utilized by end users for development purposes, as shown by the examples in Chapters 2 and 3. Cognitive models, in particular, help to move away from monitoring to anticipatory actions.[13]

Leveraging these innovative digital applications takes place in a fast-changing context characterized by many factors, including active private sector participation in creating space-based products and services, increased smart and automated digitization of vital geographic information system (GIS) parameters, and active use of cognitive models (including artificial intelligence, machine learning and deep learning). Despite occurring at an uneven pace across countries, the increased digitization, during the COVID-19 pandemic, reflects an important trend that will shape future geospatial information applications in the region. For example, the progress that South-East Asian countries have made in expanding mobile coverage (2G, 3G and 4G), could be capitalized to benefit a broad segment of the population.[14] Coverage of mobile networks in Brunei Darussalam, Indonesia, Malaysia, Singapore, Thailand and Viet Nam is well over 95 per cent. Nevertheless, infrastructure development, research and development, and domestic technology advancements must remain on course to achieve the SDG target.[15]

The potential to transform development practices, including the application of geospatial information, cannot be underestimated when millions of people are connected by mobile devices with unprecedented processing power, storage capacity, and access to knowledge and information. Emerging technological breakthroughs, in fields such as artificial intelligence (AI) , robotics, the Internet of Things (IoT), autonomous vehicles, 3-D printing, nanotechnology, biotechnology, materials science, energy storage, and quantum computing, increase this transformative power in a substantial way.[16] Figure 1.2 shows some of the benefits of these technologies for disaster risk reduction and health care.

Figure 1.2: Technologies for disaster risk reduction and resilience and health care

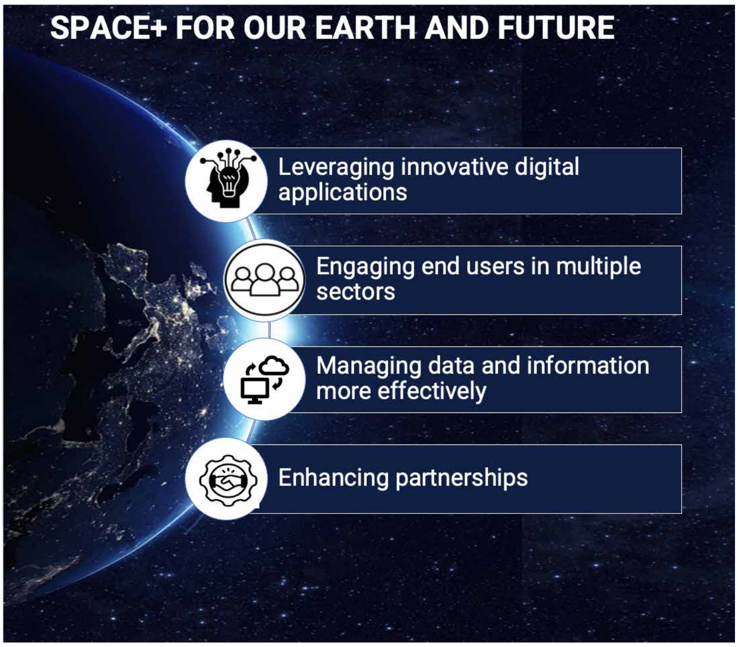


Source: ESCAP, 2021.

Space+ for our Earth and future

Mindful of the transformative potential of innovative digital innovations to promote space applications for sustainable development, the Intergovernmental Consultative Committee (ICC) on the Regional Space Applications Programme for Sustainable Development (RESAP), at its twenty-fourth and twenty-fifth sessions, recommended "Space+ for our Earth and future" as the guiding theme for accelerating the implementation of Phase II of the Plan of Action. Leveraging innovative digital applications is one of the foundational elements, along with engaging end users, including the private sector and youth. Other elements include managing data and information more effectively, and enhancing partnerships with national, regional and global stakeholders (Figure 1.3).

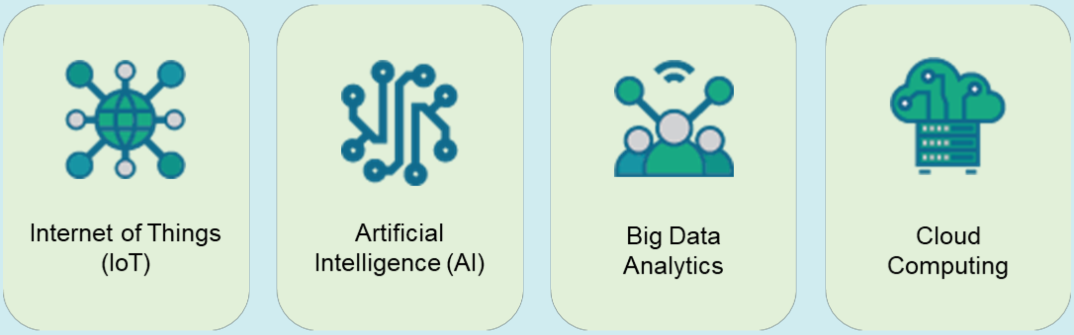
Figure 1.3: The elements of Space+ for our Earth and future



The idea of Space+ is to build the capacity of countries to leverage a powerful combination of these technology-based innovations, capacity-building, and integrated approaches to space applications that would enable countries to accelerate progress on the SDGs. Regional cooperation, envisioned under Space+, focuses on enabling countries to leverage the innovative applications of fourth industrial technologies that are game changing in the field of space applications (Box 1.2).

Box 1.2. Fourth industrial revolution technologies for space applications[a]

Figure 1: **Fourth industrial revolution technologies**



Internet of Things (IoT)

IoT is a system of interrelated sensors and the ability to share data over a network without requiring human-to-human or human-to-computer interaction. The IoT and geospatial data are coupled through the geographic location provided by Global Navigation Satellite System (GNSS) based positioning systems.

For example, a study aiming to understand specific crop variables across a large cropping area demonstrated that it is possible to install automated weather stations (AWS) to monitor local weather parameters (precipitation, wind speed and direction, humidity, temperature, among others); soil moisture; water level; field-level imaging, amongst others, for agricultural monitoring. These sensors, installed on AWS, have the potential to share specific parameters, through a web-enabled base station, allowing for remote analysis of field conditions via simple mobile applications. Collectively, all sensors installed at specific points, with GNSS location data, form a sensor web on the ground that can monitor a range of important parameters. The data collected by these devices can be automatically analysed by artificial intelligence-enabled analysis tools to facilitate real-time and informed decision-making.

Using location-based geospatial applications, such configurations and architectures can be monitored and analysed from remote locations. IoT has a plethora of applications for natural resources monitoring and management, and all of these can be seamlessly integrated into geospatial applications effectively to achieve the SDGs. Examples of this are Thailand's natural resource management platforms and the Singapore/Malaysia marine spatial information hubs (See Chapter 2).

Artificial Intelligence (AI)

AI is a broad area of computer science, that aims to create systems that function intelligently and independently. AI enables systems to interpret data correctly, learn from it and utilize it to accomplish objectives and activities. Based on this ability, AI has the potential to be used for the analysis of space data, particularly in inferencing historical and future trends in natural resource use, weather patterns, and socioeconomic patterns over time. Access to infrastructure and technology, quality datasets, and computing power and complete solutions is driving the adoption of AI in the region. The ESCAP secretariat, with support from other member States, can facilitate capacity-building and adoption of AI to achieve SDGs by developing readily deployable AI packages which avoid the traditional pitfalls of AI technology adoption, such as onboarding of AI domain experts, time-consuming system integration and lack of transparency.

Big data analytics

Big data refers to data sets of increasing volume (amount of data), velocity (speed of generating data) and variety (type of data). Big data is often largely unstructured, meaning that they have no pre-defined data model and/or do not fit well into conventional relational databases. Big data is valuable as input for decision support systems, either on its own or in combination with more traditional data sources. However, harvesting the information from big data and incorporating it into a decision-making process is not easy and requires the use of a specialized process called big data analytics.

Big data analytics is a process by which an analyst uses this domain to extract meaningful insights, such as hidden patterns, previously unknown correlations, inherent trends, and user preferences, to facilitate efficient decision-making. Big data analytics provides various advantages, such as better decision-making and access to large scale, on-demand data. Big data platforms ensure that the data is well organized for various operations, including the metadata analysis, so that data fetching is achieved optimally, and also helps in deriving inferences from massive data pile-up rapidly and efficiently. Today, there are millions of data sources that generate data at a very rapid rate, which can be utilized for analysis. Geospatial data is crucially linked with big data, which together allow for better multidimensional and temporal insights, and provide rapid and important analyses for (a) risk management; (b) policy and project development; (c) efficient decision-making; (d) prescriptive and predictive analytics, and many more.

National or regional-level data from multiple themes can form an enormous database, and such information needs to organized into a big data structure to be effectively utilized. Specific software tools can be used to assemble and organize data, and to build analytics over such databases. Geodatabases can also be organized on a big data platform and be efficiently handled for large-scale usage. Member countries could easily adapt such tools and technologies to meet national and regional needs related to the SDGs and the Plan of Action.

Cloud Computing[b]

Cloud computing is a new paradigm that simplifies computer infrastructure by ensuring that the necessary platforms and tools are always available for any given situation. This effort simply entails delivering hosted services, such as servers, software, databases and analytics over the Internet or 'the cloud'. These services are classified into three categories: Infrastructure as a service (IaaS); Platform as a service (PaaS); and Software as a service (SaaS). A cloud could be broadly categorized into 'private' or 'public'. A public cloud provides services to anyone over the Internet on commercial grounds. A private cloud is a proprietary network or a data centre that supplies hosted services to a limited number of people with certain access and permissions settings. The objective of cloud computing is to provide easy, scalable access to computing resources and information technology (IT) services. This outcome means that heavy investment on building an exclusive institutional infrastructure is not required; rather the cloud services could be hired at a more affordable financial and operational cost thereby offering a simpler and more efficient mechanism for IT infrastructure.

Geospatial data has been adopted to cloud computing recently and more professionals are now making use of cloud-based systems to store, manage, analyse, visualise and access geospatial data. Cloud computing facilities could be adopted by member countries to analyse big Earth data and host their sharable database and their geospatial solutions. This is especially necessary in countries that lack adequate technical and digital capacities and need to scale up their digital systems, quickly and efficiently. Additionally, the cloud computing system is designed to ensure a high level of data security and reliability using cutting-edge data security protocols. The advantage of these tools is that they enable rapid implementation of the database and analytical design, allowing software and data services to be deployed on the platform without waiting for infrastructure to be built. As a result, cloud-based applications are becoming more popular globally for all major IT-based solutions.

a. Diwakar Parsi, Technical paper commissioned by ESCAP for the Expert Group Meeting on Integration of Space, ICT & Geospatial Applications in "SPACE+ for our Earth and Future", 2021.
b. Ibid.

Conclusion

The independent evaluation of the implementation of Phase I of the Plan of Action finds that it has been an effective instrument for aligning the capacity development programmes of the Economic and Social Commission for Asia and the Pacific (ESCAP), and of its member States, with the priority needs of countries. This has resulted in greater harmonization of regional actions, reduced duplication of efforts, enhanced cooperation among various agencies and stakeholders, and strengthened partnerships at different levels.[17]

As one of the instruments for sharing knowledge, identified by the Plan of Action, this Compendium highlights some of the key achievements of South-East Asian countries. Achievements beyond South-East Asia are featured in a separate report by the secretariat.[18] The chapters that follow, Chapters 2 and 3, will feature many of these achievements which have been contributed by South-East Asian member States, and supplemented by several development partners. The discussions in the proceeding chapters will include how countries are already operationalizing Space+ to capture the socioeconomic benefits of emerging fourth revolution technologies and their applications. Persistent capacity needs and gaps will be examined, in Chapter 4, based on findings from ongoing discussions via ESCAP platforms. Finally, the Compendium will conclude with some recommendations for consideration by ESCAP member States to accelerate the implementation of the Phase II of the Plan of Action.

Endnotes

1. ASEAN Science & Technology Network (ASTNET) (2021).
2. ESCAP (2022a).
3. For more information see the UNOSAT FloodAI and UNOSAT Emergency Mapping Programme, in Chapter 2, and Chapter 3.
4. For more information see Viet Nam: Viet Nam Natural Disaster Monitoring System (VNDMS) in Chapter 2.
5. For more information see Indonesia: SDG monitoring in Chapter 2.
6. For more information see Thailand: Creating a database of low-income communities from aerial imagery in Chapter 2. See also Asian Development Bank (2021).
7. For more information see Singapore: Traffic Watch makes use of spatial data to tackle road congestion in Chapter 2.
8. For more information see Cambodia: Geospatial modelling for emergency service road access to rural access in Chapter 2.
9. For more information see Singapore: Virtual 3D Platforms in Chapter 2.
10. For more information see ASEAN (Indonesia, Malaysia, Thailand and Viet Nam): Monitoring plastic waste in Chapter 2.
11. For more information see Asia: Pan-Asia Partnership for Geospatial Air Pollution Information (PAPGAPI) in Chapter 2.
12. For more information see Thailand: Thailand: Renewable energy projects in Chapter 2.
13. ESCAP (2022c).
14. ESCAP (2022a).
15. ESCAP (2022a).
16. Klaus Schwab (2016).
17. Tadashi Nakasu (2022). Evaluation of the Implementation of the Asia-Pacific Plan of Action on Space Applications for Sustainable Development (2018-2030) in its Phase I (2018-2022).
18. ESCAP (2022b).

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Secretariat of Indonesian Space Agency, National Research and Innovation Agency of the Republic of Indonesia (2022). Agenda item 2: Progress in Implementing the Asia-Pacific Plan of Action on Space Applications for Sustainable Development (2018-2030), 26th session of the Intergovernmental Consultative Committee (ICC-25) on the Regional Space Applications Programme for Sustainable Development (RESAP). 18 August. Jakarta. Indonesia. Available at https://www.unescap.org/sites/default/d8files/event-documents/Indonesia%20.pdf

United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) (2022a). *Asia and the Pacific SDG Progress Report 2022: Widening disparities amid COVID-19*. United Nations publication.

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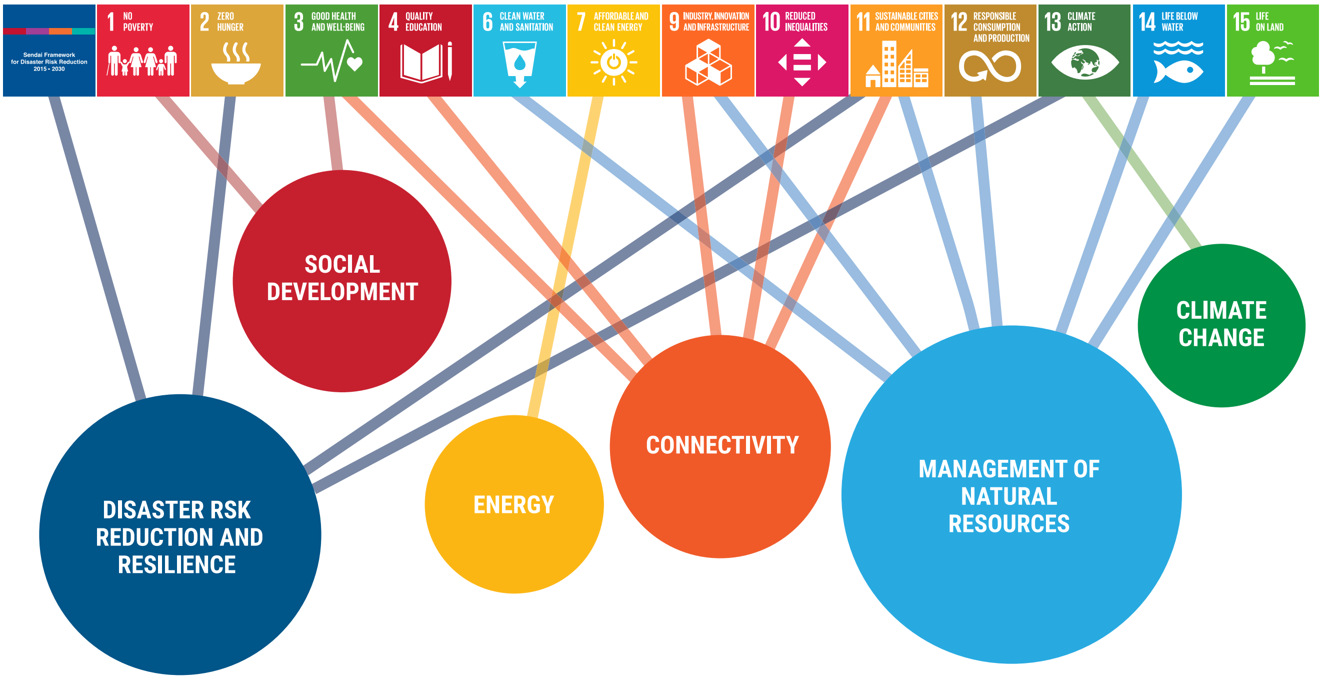
Chapter 2

Geospatial Practices for Sustainable Development in South-East Asia

The Asia-Pacific Plan of Action on Space Applications for Sustainable Development (2018–2030) aligns with ESCAP's Regional Roadmap for Implementing the 2030 Agenda for Sustainable Development in Asia and the Pacific.[1] The Plan of Action includes 188 actions in the following 6 thematic areas: (a) disaster risk reduction and resilience; (b) management of natural resources; (c) connectivity for the 2030 Agenda for Sustainable Development (d) social development; (e) energy; and (f) climate change. All 188 actions are intended to contribute to 37 targets of 14 selected goals of the 2030 Agenda for Sustainable Development (Figure 2.1). This chapter highlights around 60 good practices from South-East Asian countries, organized under the above-mentioned 6 priority themes.

Figure 2.1: Integrating Geospatial Dimensions for a Sustainable Asia-Pacific Region: Alignment of the Plan of Action with the Sustainable Development Goals

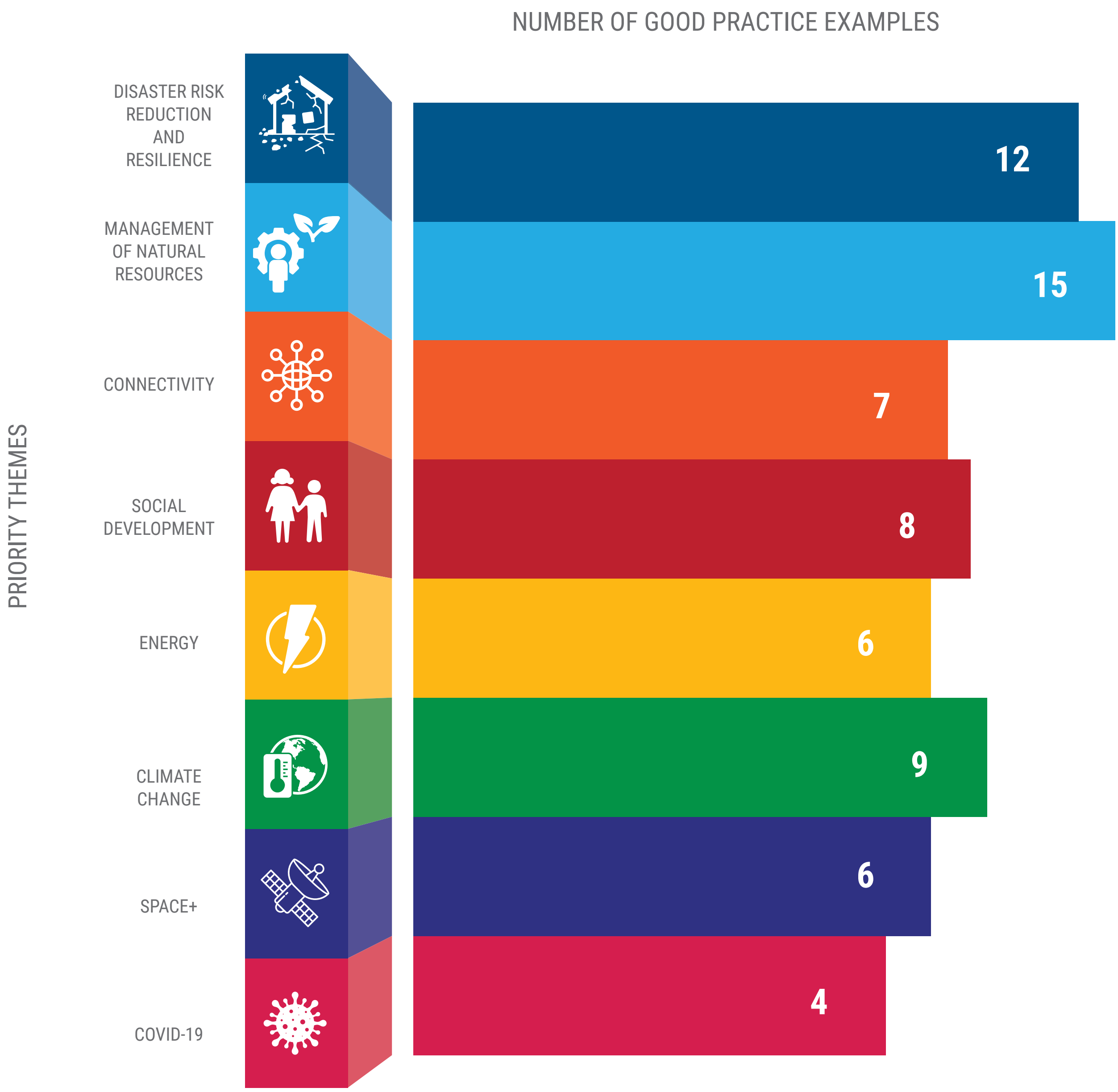


Source: United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), "Asia-Pacific Plan of Action on Space Applications for Sustainable Development (2018-2030)", (2018).

Other relevant topic areas which are discussed in this chapter include Space+ and the COVID-19 pandemic. Space+ is the theme of the upcoming Fourth Ministerial Conference on Space Applications for Sustainable Development in Jakarta, and undoubtedly, the COVID-19 pandemic has played a large role in global events. All examples and good practices, presented within this chapter, fall under Phase I (2018–2022) of the Plan of Action, and show applicable case scenarios of accessible, available, affordable and actionable uses of geospatial information.

To compile this summary, countries within the South-East Asian region were asked to contribute examples of good practices within the six thematic areas to highlight their progress towards the SDGs, the Regional Road Map and the Plan of Action. The secretariat disseminated a comprehensive questionnaire to all members of the Regional Space Applications Programme for Sustainable Development (RESAP), requesting information and details on actions that have been undertaken during Phase I of the Plan of Action. This questionnaire aimed to capture activities and initiatives under the six priority themes, along with cross-cutting examples. To fill gaps in information, additional research and knowledge-sharing was also undertaken (Table 2.1).

Table 2.1: Themes discussed throughout this chapter

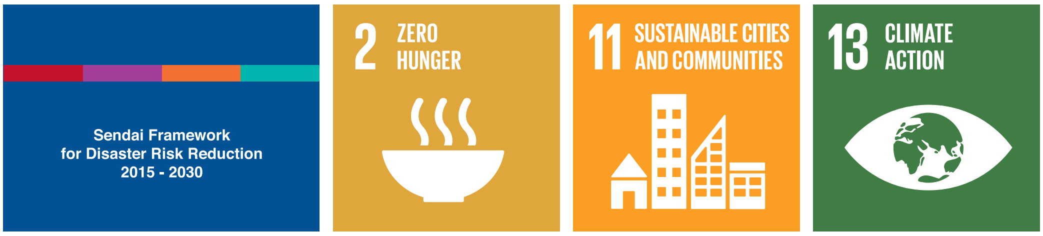


Additionally, each good practice, mentioned in this chapter, will include the relevant sub-theme icons, which fall under the six themes of the Plan of Action (Table 2.2). The icons will provide a visual illustration of how the wide range of examples are a path toward the implementation of the priority areas within the Plan of Action. Furthermore, these icons highlight the cross-cutting and interdisciplinary nature of each country's practices.

Table 2.2: 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	Coastal 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

Theme 1 - Disaster Risk Reduction and Resilience



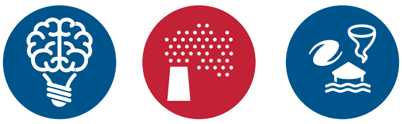
The Asia-Pacific region is the most disaster-prone region in the world, with South-East Asia being specifically affected by several natural hazards, namely floods, droughts, and typhoons. Over the last several years, millions of people across the region have been affected by these disasters, through displacement and damage to houses and infrastructure.

The use of space applications, including geographical information systems (GIS), can be leveraged within this context to enhance measurement tools, data collection, data analyses and dissemination of data. Space applications can contribute to disaster risk reduction, mitigation, preparedness, response and recovery.

Countries within South-East Asia are already leveraging these technologies to improve their disaster management strategies in line with global agendas.

Innovation in disaster preparedness and management

1. Asia: Pan-Asia Partnership for Geospatial Air Pollution Information (PAPGAPI)



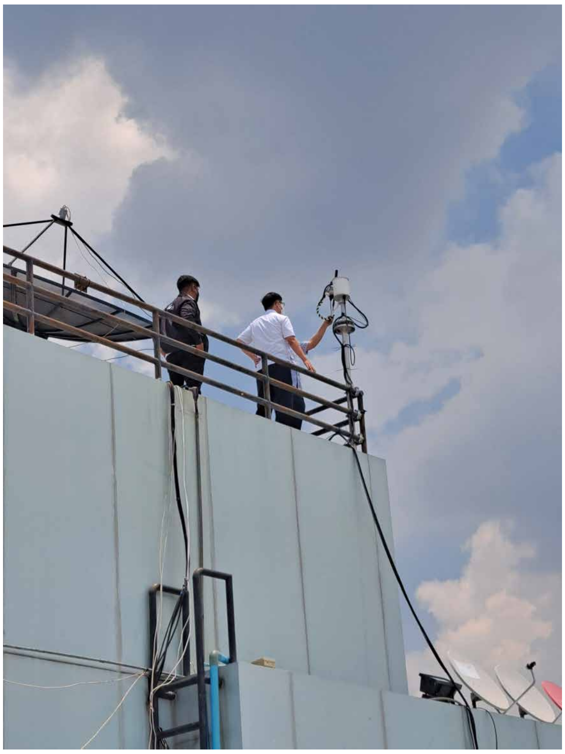
The Pan-Asia Partnership for Geospatial Air Pollution Information (PAPGAPI)[2] is boosting the capacity of over 10 countries to monitor and manage air pollution through geodata and satellite applications. Developed by the Republic of Korea, integrated surface-based data from the Pandora spectrometer instruments and satellite data from the Geostationary Environment Monitoring Spectrometer (GEMS), are being utilized (Figure 2.2).

The main objective of this project is to share data on air quality, including air pollutants and climate change-inducing gases, with Asian countries. Key activities that will be undertaken include needs assessment and selection of pilot countries. This will help to understand the capacity and needs of member States to operate, maintain, effectively use and calibrate GEMS data. Key actions include:

- Capacity-building and development of training materials, which will be tailored to each pilot country based on the needs assessment;
- Processing and development of applications to use data;
- Developing a regional partnership;
- Building capacities for member States to use integrated satellite and ground data for improving operational monitoring, which can potentially inform future efforts to increase regional cooperation to address air pollution.
- Facilitating technology transfers, enabling data-sharing, capacity-building, and providing international cooperation initiatives on air pollution.

This project is at the forefront of air pollution monitoring with GEMS being the first satellite sensor, in the world, that observes air pollutants (fine dust, sulphur dioxide, nitrogen dioxide, ozone, formaldehyde, etc.) from geostationary orbit over most parts of Asia (Figure 2.3).

Figure 2.2: **Technical visit of the Pandora instrument installation site by an expert from the National Institute of Environmental Research officials and Pukyoung National University, 1 September 2022**



Source: ESCAP (courtesy GISTDA), (2022).

Figure 2.3: **Pandora instrument installation on a rooftop of the Chiang Mai Rajabhat University**

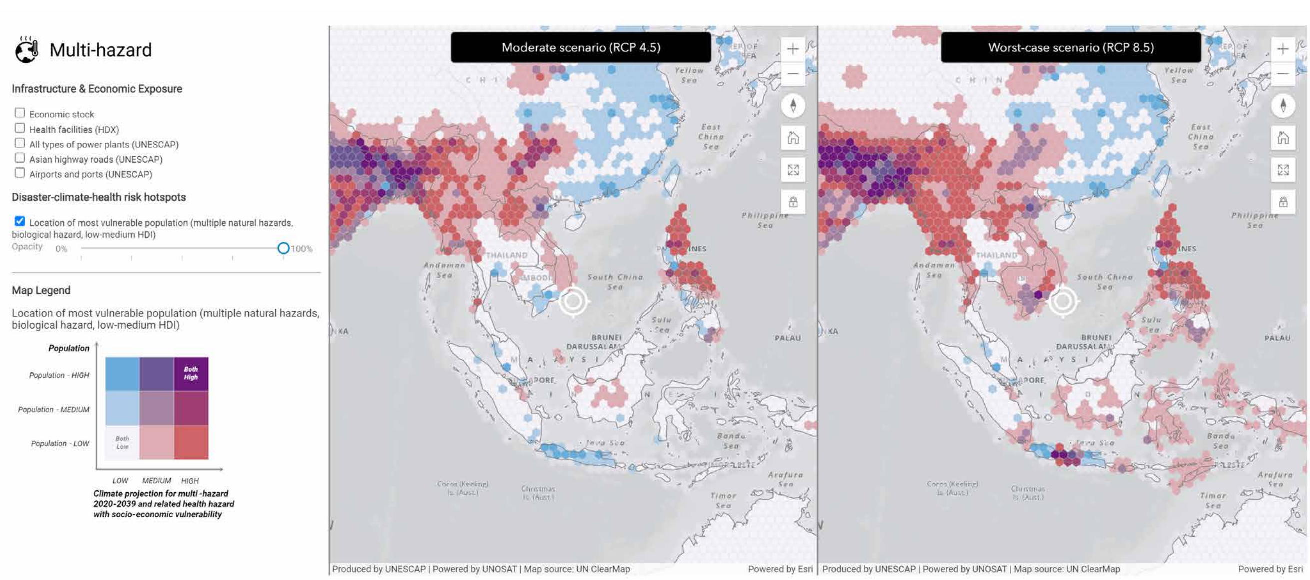
Source: ESCAP (courtesy GISTDA), 2022.

2. Risk and Resilience Portal: An initiative of the Asia-Pacific Disaster Resilience Network

The Risk and Resilience Portal has been developed by ESCAP and the United Nations Satellite Centre (UNITAR-UNOSAT).[3] The portal is a digital platform that serves as a one-stop shop for policymakers to understand the regional, subregional, and national 'riskscape' of hazard and climate risks, and utilize adaption measures to build resilient economies and safeguard populations. Using a variety of methodologies, the portal converts the vast array of publicly available geospatial, statistical, and remote-sensing information on hazards, climate change and socioeconomic data into usable and interoperable data analytics for risk informed decision-making. It further provides targeted adaptation solutions for countries based on their risk profile.

Statistical applications of global spatial datasets on natural and biological hazards, health-related indicators, and socioeconomic vulnerability indices are used to identify pockets of complex and cascading risk hotspots at the regional, subregional, and national level. Economic impacts are estimated based on probabilistic methods designed to calculate average annual loss in a period under two climate scenarios; moderate (RCP 4.5), and worst-case (RCP 8.5) scenarios. Finally, targeted adaptation solutions are derived based on indexed indicators used to estimate the cost and priorities of five key adaptation measures (Figure 2.4).

Figure 2.4: Risk and resilience portal: Disaster-climate-health risk hotspots



Source: ESCAP. Asia Pacific Risk and Resilience Portal. Available at https://rrp.unescap.org

For each country/subregion of interest, the portal ensures that users can first understand the risks and economic impacts. The portal then calculates the estimated adaptation cost required to address the risks and finally, recommends key adaptation solutions to minimize the risks and become resilient. The portal also offers customizable prototypes of subnational and district level risk analysis with the Decision Support System (DSS) for select countries across the region. This feature presents a systematic and transparent approach to visualize, compare, and rank disaster risk at the subnational level.

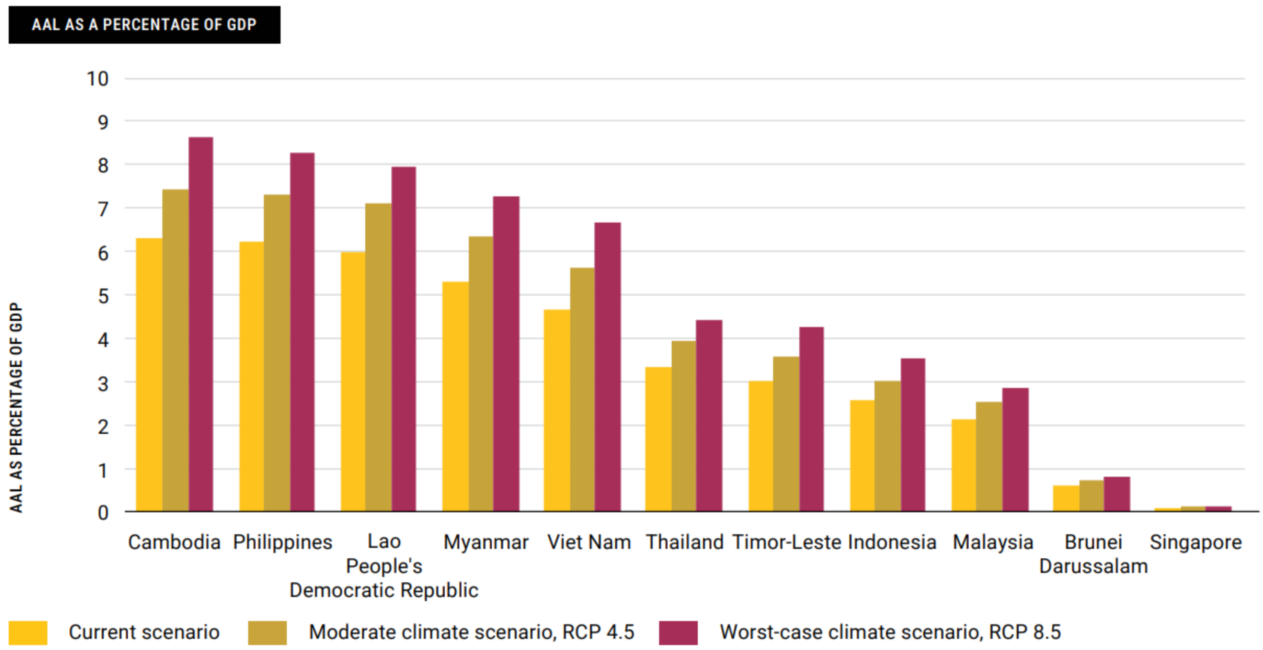
This portal is also equipped with a Decision Support System (DSS), which provides contextual analysis of risk based on Sub-National INFORM Risk Index to support informed decision-making for selected countries across the region. This feature presents a systematic and transparent approach to visualize, compare, and rank disaster risk at the subnational level.

It effectively bridges the science-policy gap as it allows both technical and non-technical users to understand risk and facilitates decision-making at the local level. Overall, the portal aims to translate global risks into evidence to help policymakers develop resilience in their communities, countries and regions.

South-East Asia: An example

Based on the latest Intergovernmental Panel on Climate Change (IPCC) report, South-East Asia is analysed with temperature increases of 1.5°C and 2°C under two Shared Socio-economic Pathways (SSPs) scenarios. The disaster riskscape highlights intensity and frequency in weather events, such as tropical cyclones, typhoons, cyclones, droughts, and floods, with South-East Asia experiencing a wetter climate and increased risks of flooding in the Mekong River Basin under both the 1.5°C and 2°C climate-change scenario.[4]

Figure 2.5: Total average annual loss (AAL) as percentage of GDP under current, moderate (RCP 4.5), worst-case climate (RCP 8.5) scenarios



Source: United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), "Pathways to Adaptation and Resilience in South-East Asia: Subregional Report", Bangkok, 2022c. Available at https://www.unescap.org/kp/2022/asia-pacific-disaster-report-2022-escap-subregions-pathways-adaptation-and-resilience-0?fbclid=IwAR0REvmCOw-vyGj0pkk-Q0dWJ-V309Pd4tEaPV5pDnUYGg1zobxb17MVp0I

Given the riskscape of South-East Asia, the Risk and Resilience Portal provides the estimated cost of adaptation to natural and biological hazards in absolute terms and as percentage of GDP for each country and subregion (Figure 2.5).

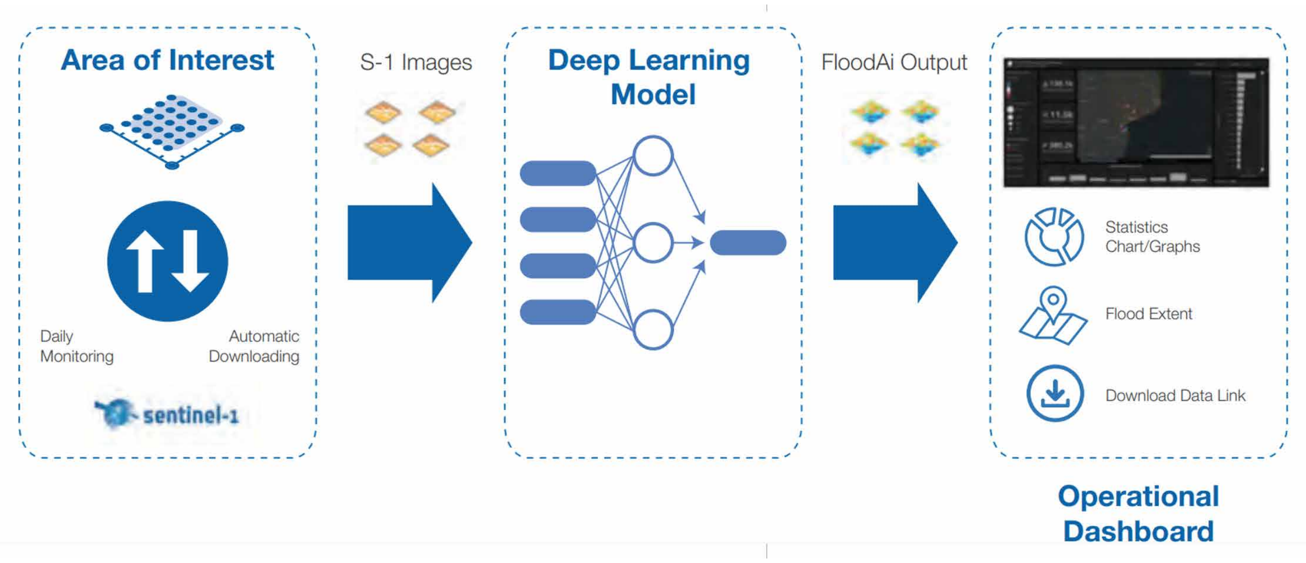
Informed by the riskscape, the portal shows that the top adaptation solutions, within the Asia-Pacific region, are protecting mangroves and making water resources management more resilient, followed by strengthening early warning systems, improving dryland agriculture, and making new infrastructure resilient. These adaptation measures are expected to yield a high investment cost-benefit ratio, and also support countries in their progress toward achieving multiple SDGs.

Countries within the region can utilize this online platform to gather geospatial data and statistics to inform decision-making across multiple sectors, including disaster risk reduction and climate change adaptation.

3. UNOSAT FloodAI: Available for multiple countries in South-East Asia

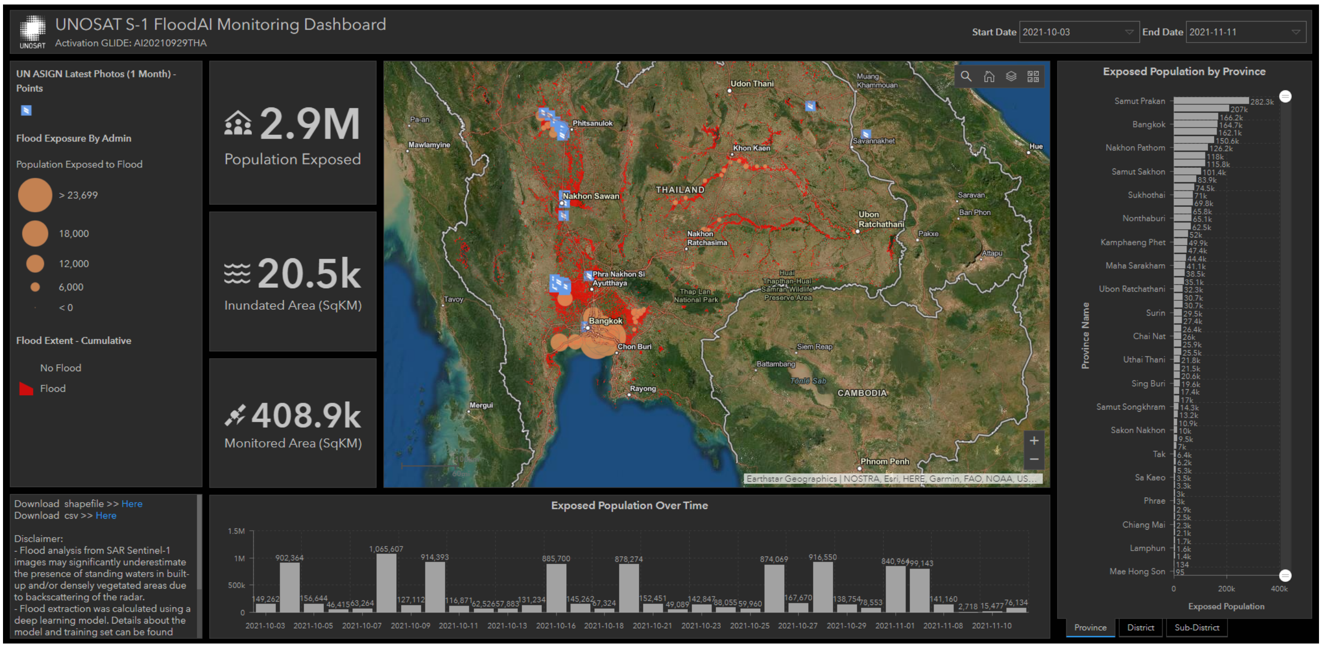
UNOSAT recently launched the UNOSAT FloodAI: an end-to-end pipeline where Copernicus Sentinel-1 Synthetic Aperture Radar (SAR) imagery is automatically downloaded and processed by a deep learning model to generate flood-extent maps and update operational dashboards. The model is based on a fully convolutional neural network that takes SAR imagery as input and returns a semantic segmentation flood mask. Combining a deep-learning model embedded within an automation pipeline allows for the processing of a large amount of satellite data in near-real-time. UNOSAT FloodAI is also able to produce the dynamic flood updates and generate automatic statistics regarding the exposed population (Figure 2.6 and 2.7).

Figure 2.6: UNOSAT FloodAI: Data processing pipeline



Source: The AHA Centre, "ASEAN Risk Monitor and Disaster Management Review (ARMOR)", 3rd Edition, June 2022.
A recent review of existing deep learning methods for flood mapping carried out by researchers reveals that FloodAI achieves highest accuracy among the reviewed approaches.[5]

Figure 2.7: UNOSAT FloodAI: Operations Dashboard for Thailand Flooding, 2021



Source: United Nations Satellite Centre (UNOSAT), "S-1 FloodAI Monitoring Dashboard", 2022. Available at https://unosat-geodrr.cern.ch/portal/apps/opsdashboard/index.html#/8398ab9339344affa2277f0031881b16 (accessed on 5 October 2022).

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

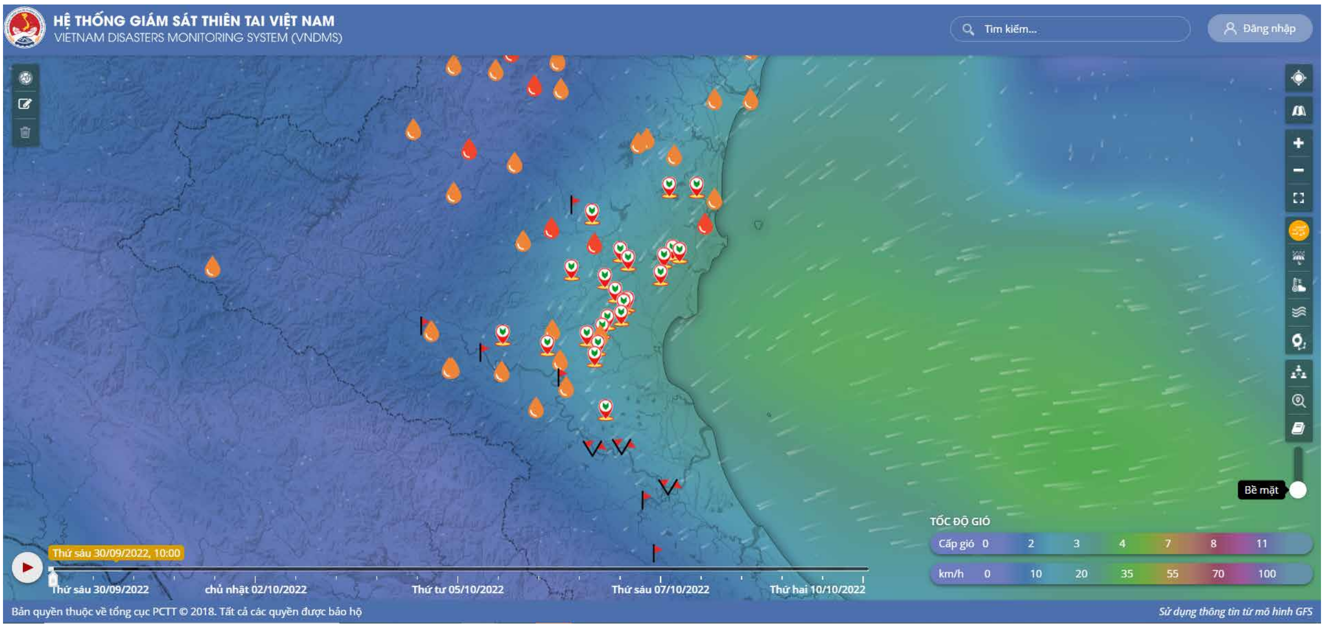
The UNOSAT FloodAI is now fully trained and operations are ready for South-East Asian countries, namely Viet Nam, Cambodia, Myanmar, and Thailand. Through collaboration with national stakeholders, the tool could be further improved to be deployed in other ASEAN countries as required.

Risk reduction, disaster assessment and emergency response

4. Viet Nam Natural Disaster Monitoring System (VNDMS)

In 2018, The Viet Nam Disaster Monitoring Authority (VDMA) developed a multi-hazard early warning system called the Viet Nam Natural Disaster Monitoring System (VNDMS)[6] for integration and monitoring information in real and near-real time (Figure 2.8). This includes data, such as hydro-meteorological data, reservoir data and bathometric data, which is combined with existing data on disaster prevention activities, dikes and local disaster prevention resources.

Figure 2.8: Screenshot of the VNDMS platform



Source: Viet Nam Disasters Monitoring System (VNDMS) (n.d.). Available at http://vndms.dmc.gov.vn/. (accessed on 14 September 2022).

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 VNDMA has developed a Disaster Monitoring Application (App-VNDMS) to support the disaster prevention personnel operating the VNDMS for data analysis. The main features of the app include alerts of natural disaster events, disaster warning, field data updates, rainfall over 50mm/24 hours, strong wind updates and above normal water level rise in discharging irrigation/hydropower reservoirs.[7]

5. Indonesia: Remote sensing data to support disaster management[8]

Fast, precise, affordable and accessible remote sensing information is expected to increase support for disaster management in building an accountable and robust system that serves as a reference in disaster emergency response activities. Indonesia is undertaking several initiatives to leverage remote sensing and big data to support disaster management and monitoring. These include:

a. Land subsidence monitoring;
b. Disaster risk monitoring through different geospatial methods, such as Standardized Precipitation Index, Vegetation Index, Fire Danger Rating System, fire hotspot and potential flood maps;
c. Monitoring the local implementation of SDGs to support decision-making in tackling critical issues in selected pilot cities (i.e., Makassar and Bandung);
d. Development and operation of hydro-meteorological disaster early warning system (SADEWA) to monitor extreme rainfall, over the Indonesian region, based on satellite observation and atmospheric models;
e. Development and operation of the Indonesia Water Vapor Tomography Information System (GATOTKACA) based on GNSS radio occultation technique to support hydro-meteorological disaster early warning system;
f. Development of a web-based operational platform to monitor daily potential hazard zones and vulnerabilities, to be shared among decision makers and stakeholders.

6. Malaysia: Remote sensing to assess impacts of oil spill on mangrove forests[9]

Oil spills that occur on the ocean surface pose a significant and lasting threat to the health of mangrove forests. Satellite imagery and remote sensing methods are extremely valuable in detecting oil spills as they allow for rapid delineation of the location, can calculate the extent of the contaminated sites, and can assist in determining the impact on environment.

Scientists in Malaysia researched and evaluated the impacts of oil spills on the mangrove forest in Pantai Cermin, Negeri Sembilan. They used open-source satellite data from the Sentinel Program, Synthetic-aperture radar (SAR) images from Sentinel-1, and multispectral images from Sentinel-2 in their study. The Random Forest classification method was used to detect the oil spill areas, with analysis of the Sentinel-1 images which showed a 76 per cent accuracy. Vegetation indices were then used to quantify the health of the mangroves in the spill areas, using a normalized difference vegetation index (NDVI) measurements which studied plant health, comparing it over a period of time. From this research, physical suffocation and toxicological effects to the mangrove forests were identified.

Such research highlights the use of open-source data, which can be easily replicable in neighbouring countries, and provides clear examples of methodologies that can aid in the monitoring and identification of mangrove vulnerability, as well as on mangrove health if an oil spill occurs.

7. Philippines: Utilizing ICT and geospatial applications for disaster preparedness

The Department of Science and Technology (DOST) of the Philippines is utilizing ICT and geospatial applications to minimize the risk of disasters due to natural hazards in the country. Several initiatives have been undertaken by the DOST to enhance the disaster risk reduction framework of the country. Some of these initiatives are highlighted below:

The Remote Sensing and Data Science (DATOS) Help Desk

The Remote Sensing and Data Science (DATOS) Help Desk is a project initiated by the Department of Science and Technology's Advanced Science and Technology Institute (DOST-ASTI). It aims to produce and communicate relevant disaster information to agencies and key end-users to complement the current efforts of existing government agencies and initiatives. DATOS builds on and integrates past and ongoing DOST-supported projects; and different GIS, remote sensing (RS) and other data science techniques.

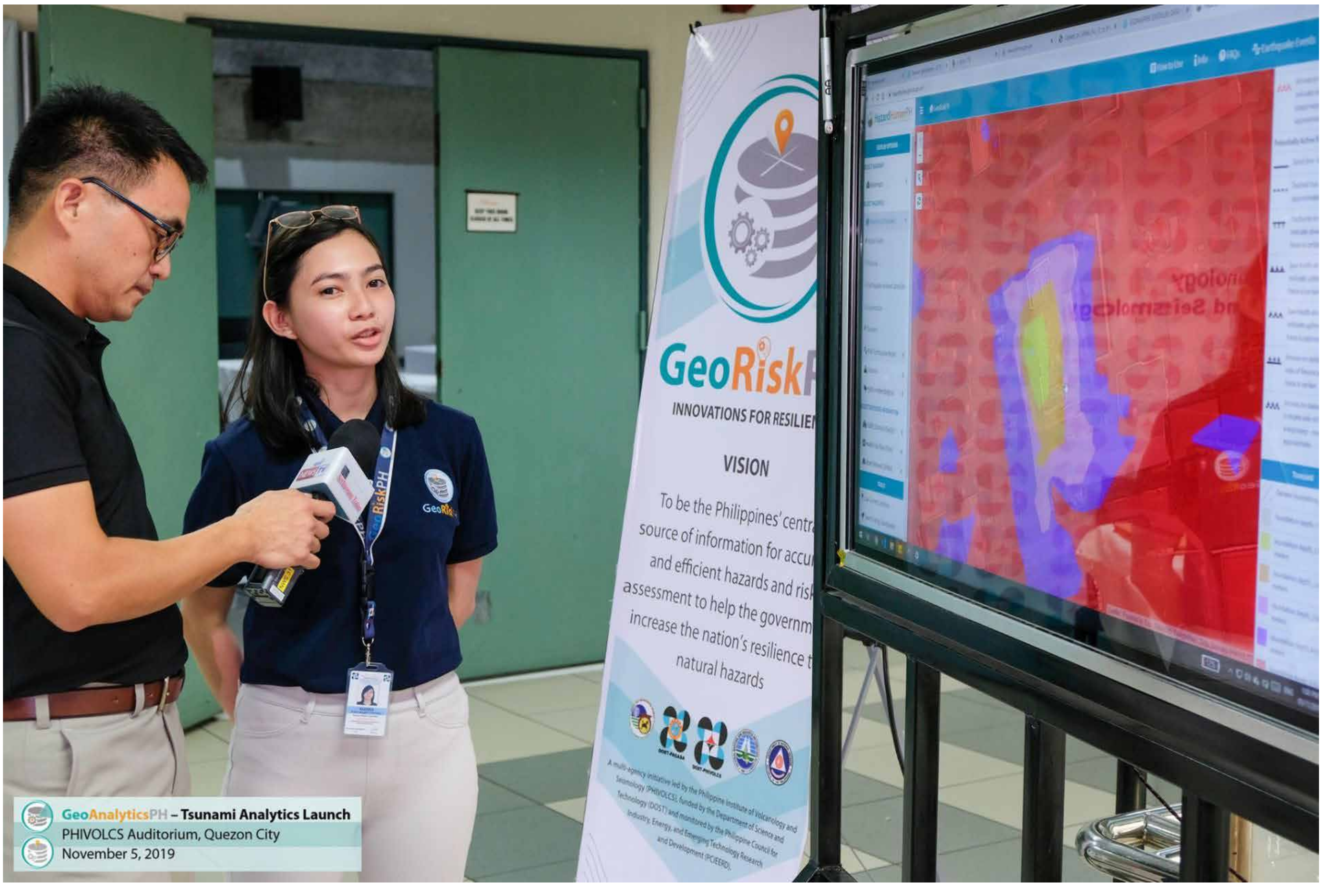
DATOS capitalizes on the current advancements of computing technology and applies it in the fields of GIS, remote sensing, artificial intelligence and data science to provide maps and other information for applications of disaster risk reduction. Components of this project are being integrated to PhilSA operations, as part of the ongoing transition.

GeoRisk Philippines

The GeoRisk platform[10] is a multi-agency initiative led by the Philippine Institute of Volcanology and Seismology (Phivolcs) and supported by the DOST. It has been developed to make hazards, exposure, risk and other data and information available for public use to improve the country's preparedness and resilience against hazards. The platform enables users to share hazard and other risk information, and rapidly generates hazard and risk assessments during a crisis.

Part of the initiative is to gather and synthesize geospatial information regarding the threat natural hazards pose to people nationwide. The project has been developed into three main apps/software which include: a) GeoMapperPH for data input, and to collect hazard and exposure information; b) HazardHunterPH to generate initial hazard assessments in selected locations; and c) GeoAnalyticsPH to generate summaries through data visualization, analysis and monitoring (Figure 2.9).

Figure 2.9: GeoRisk Portal



Source: PHIVOLCS GeoHazards Portal. Available at https://gisweb.phivolcs.dost.gov.ph/

8. Philippines: Digital twin technology for disaster response

The Philippines is considered the typhoon alley of the world with about 20 major typhoons hitting the coast annually. When typhoons occur, it is crucial to quickly and accurately identify where damage has occurred, so that the government can plan for immediate disaster response. Cauayan, a typhoon-prone city in the Philippines, has partnered with a geospatial start-up to use uncrewed aerial vehicles (UAVs), such as drones, and digital twin software for disaster recovery planning.[11] The start-up's digital twin platform converts drone images into 3D models of the city, then uses artificial intelligence (AI) to calculate how much damage has been done to houses, crops and livestock. The AI software allows users to quickly gather a report of the typhoon's aftermath, which can then be shared with national agencies to allocate resources.

The start-up plans to enhance its software to predict disasters. This means that officials would be able to run simulations using machine-learning algorithms to determine flood-prone areas. For example, the platform could pool data on COVID-19 patients, or those affected by floods and dengue so officials can get a comprehensive scenario of the issues that citizens struggle with. The digital twin platform could help towns plan and prepare for a more resilient future.

In addition, digital twin platforms would also be useful for town planning; the tool could allow the city officials to visualize new buildings for efficient design, operation and maintenance. Digital twin technology has a high range of potential, which can help users in targeting projects that seek to achieve sustainable development (Figure 2.10).

Figure 2.10: Digital Twin Project Platform

Source: Yun Xuan Poon, "How a Philippines city uses digital twins for disaster recovery", GovInsider, 18 May 2021. Available at https://govinsider.asia/climate/cauayan-graffiquo-how-a-philippines-city-uses-digital-twins-for-disaster-recovery/

9. Thailand: ThaiAWARE – An early warning and hazard monitoring system)

In 2021, the Government of Thailand and the Pacific Disaster Center (PDC) operationalized an early warning and hazard monitoring system called ThaiAWARE. The system aims at providing accessible advanced decision support capabilities to disaster managers in the country, and will aid in protecting its residents and millions of tourists who visit Thailand each year. The Government of Thailand and PDC first partnered in the aftermath of the devastating magnitude 9 Indian Ocean earthquake and tsunami of 2004 to enhance the early warning system in the country.

The ThaiAWARE system provides decision makers with actionable real-time, dynamic information from national and international sources, and has an advanced platform showing multi-hazard exposure with modelling capabilities. This comprehensive system enables Thailand's disaster managers to take rapid action in the event of a disaster, to ensure minimum loss and speedy recovery. The system includes the new early warning and multi-hazard monitoring technologies and critical predictive hazard impact analysis tools aided by the addition of several national data layers to support efficient and effective preparedness and response. It will enable Thailand's residents and tourists to receive disaster notifications for floods, wildfires, tsunamis and COVID-19 outbreaks.[12]

Food production

10. West Java, Indonesia: Integration of deep machine learning with satellite data to map paddy rice production stages[13]

Across Asia, the task of increasing rice production continues to be at the forefront of national planning agendas as the demand for rice is increasing with population growth. Various satellite applications, such as remote sensing, can be useful in estimating production, and providing information product quality and growing conditions.

In this regard, the Badan Pusat Statistik (Statistics Indonesia), in collaboration with the United States Arid Land Agricultural Research Center (USDA-ARS), has implemented a modern method for agricultural production surveys using an innovative, technology-driven, inter-disciplinary approach.

This method uses a combination of space-based data, including satellite imagery with extensive ground surveyed data. Using different machine-learning models, this study compared different learning scenarios for classifying, over time, rice paddy production stages across West Java.

Sentinel-1 synthetic aperture radar (SAR) data and optical remote sensing data from Sentinel-2 satellite data were used to map different temporal progressions for different scenarios of production. Researchers integrated the agricultural survey date by training and testing the model with monthly ground-based observations from 21,696 locations across West Java. When classifying rice production stages, five different classifications were defined: rice at tillering, heading, and harvest stages, rice fields with little to no vegetation present, and non-rice areas.

Deep-learning models, combining ground data and remote sensed imagery reached an accuracy of greater than 75 per cent for determining rice production stages. This research methodology demonstrates the value of combining space-based data, such as open-source satellite data, with modern agricultural survey data, to develop deep learning models to map rice paddy production.

11. Philippines: The Philippine Rice Information System (PRiSM)[14]

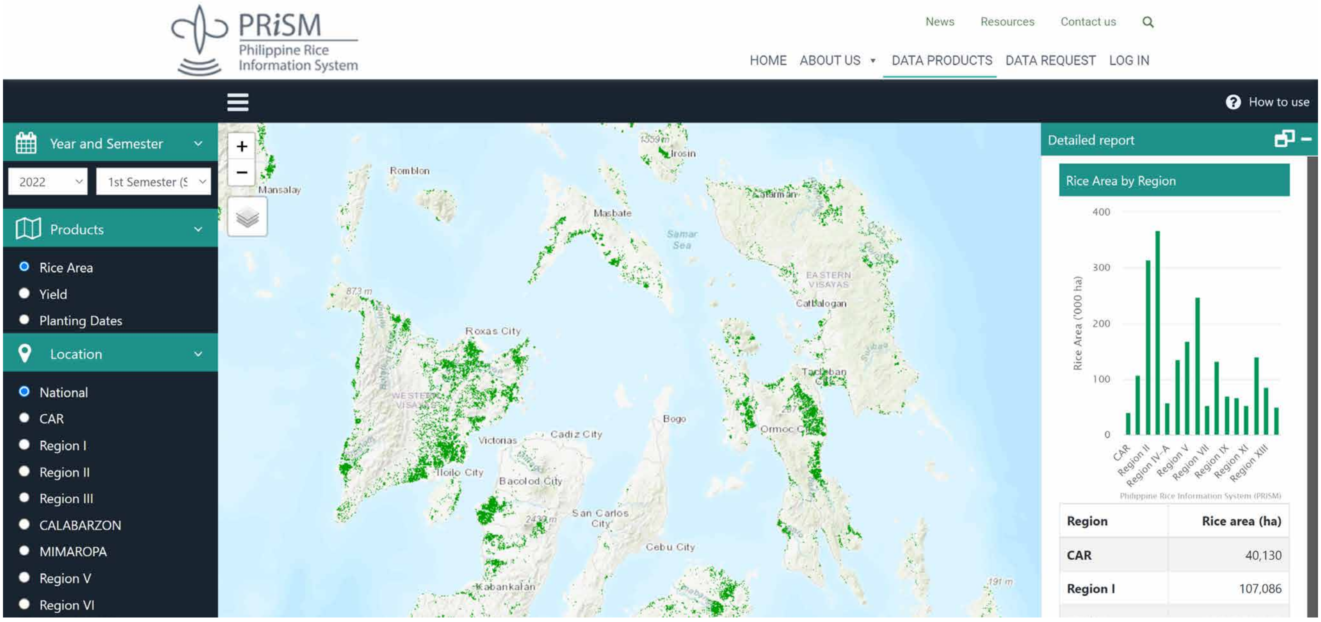
Terrestrial ecosystems and land resources management ranks highest in terms of number of identified projects and activities within the Philippines, with a variety of sub-thematic areas addressed by initiatives under this focus area.

PRiSM was a collaborative project of the Department of Agriculture (DA), the Philippine Rice Research Institute (PhilRice), and the International Rice Research Institute (IRRI) to transform the way data and information on the rice crop are created and shared. The system is now a fully functional monitoring and information system that produces timely data on rice production.

The PRiSM generates information using data from the Synthetic Aperture Radar (SAR), a rule-based algorithm, and a crop simulation model to classify rice planting areas, seasonality, productivity, and crop hazards. It also makes use of smartphones to create surveys and communicate information with end users, which can help farmers and decision-makers during times of food scarcity, floods, droughts, and typhoons.

When first operational, PRiSM was the first satellite-based rice monitoring system in South-East Asia. This usage of space applications can serve as a model for other countries within the region to use such technologies to boost agricultural production and food security (Figure 2.11).

Figure 2.11: Screenshot of the PRiSM platform



Source: Philippine Rice Information Systems (PRiSM) Platform. Available at https://prism.philrice.gov.ph/dataproducts/ (accessed on 13 September 2022).

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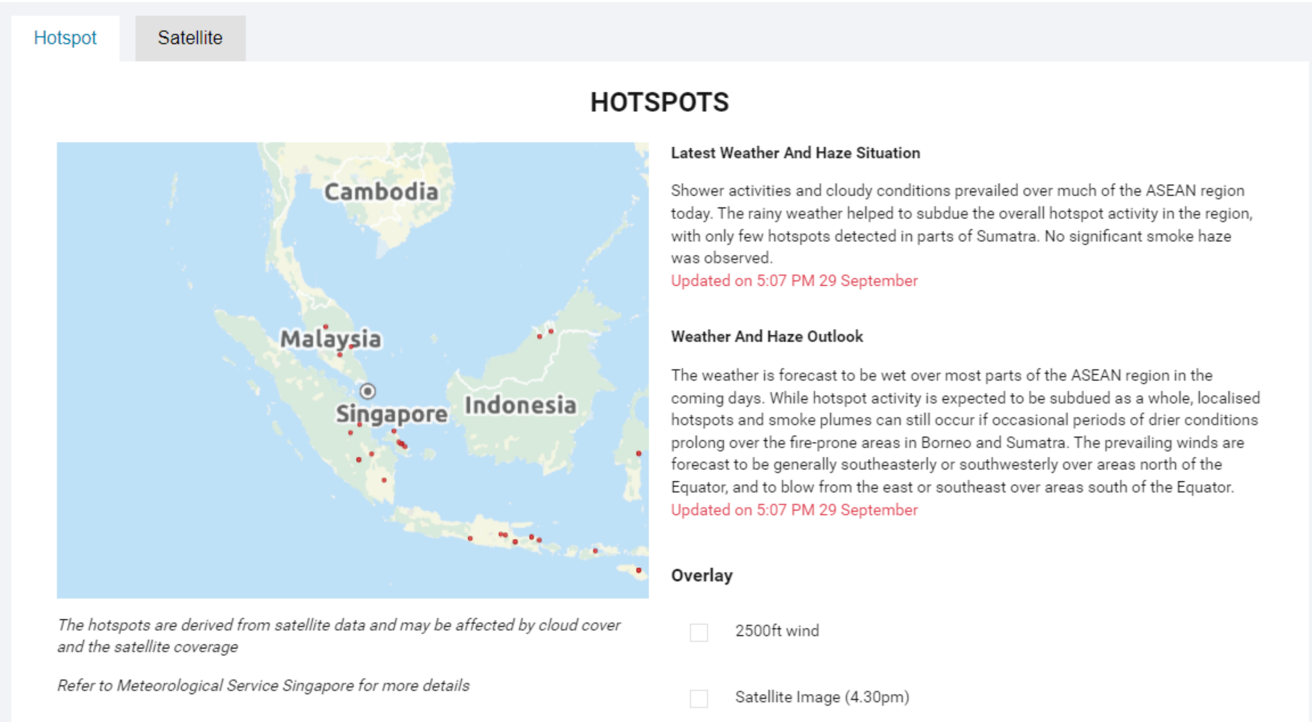
Climate hazards

12. Singapore: Regional forest fires and haze

Since the fire and haze episode of 1997/98, the Centre for Remote Imaging, Sensing and Processing (CRISP) at the National University of Singapore (NUS) established its capability in regional fire monitoring, using low resolution hotspot data from the National Oceanic and Atmospheric Administration (NOAA), and Moderate Resolution Imaging Spectroradiometer (MODIS), together with high resolution satellite images, such as those from the SPOT (from French "Satellite pour l'Observation de la Terre") and Planet satellites. Fire activities were usually quantified by the so-called "hotspots" detected in the thermal bands of environmental satellites. The hotspot data from the Advanced Very High Resolution Radiometer (AVHRR) instrument on NOAA series of meteorological satellites were taken as the "gold standard". The hotspot maps, displayed on the Singapore National Environment Agency haze website, show the latest weather and haze situation across most parts of the ASEAN region. This data can be accessed freely online for users to gain information on the latest air quality conditions (Figure 2.12).

Figure 2.12: Screenshot of haze website highlighting the current hotspots within the region



Source: National Environment Agency, 2022. Available at https://www.haze.gov.sg/ (accessed on 14 September 2022).

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However, the accuracy of hotspots was sometimes debatable due to the low saturation threshold, resulting in high false alarm rates. Another major disadvantage of its use in active fire detection was its low spatial resolution, which meant that small fires were likely to be missed. High-resolution satellites, however, usually do not carry the thermal bands required for detecting hotspots and they cannot cover large areas on a daily basis due to their narrow swath width. The fire monitoring operation at the Centre for Remote Imaging, Sensing and Processing (CRISP) uses coarse-resolution hotspot data to select areas with high concentrations of hotspots, then use high-resolution SPOT or Planet satellite data to scan for fires (by visual detection of smoke plumes, and locating fire positions to within 20m accuracy, using specialized software developed at CRISP) in these areas of interest (Figure 2.13).

Figure 2.13: A sub-scene of a SPOT satellite image showing active fires in Riau, Sumatra displayed in two false colour composite schemes. In this scheme, vegetation appears reddish. Thick white smoke plumes are clearly visible

Source: Centre for Remote Imaging, Sensing and Processing (CRISP), National University of Singapore, n.d. Available at https://crisp.nus.edu.sg

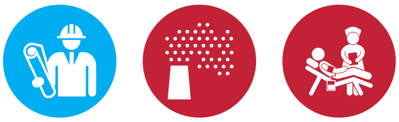
Theme 2 - Management of natural resources

The Asia-Pacific region consumes more than half of the world's natural resources, with increasing rates of absolute resource use per person. Such resource usage is putting pressure on the natural environment, and has direct economic, social and environmental consequences. Improving the use and protection of ecosystems is a priority in the ESCAP Regional Road Map for Implementing the 2030 Agenda for Sustainable Development in Asia and the Pacific, and the use of space applications can offer valuable information to support conservation and sustainable resource management.

With an increase in satellite imagery and remote sensing capabilities, these technologies will play a vital role in managing, accessing and monitoring natural resources in the coming decade. Many countries across the Asia-Pacific region, specifically in South-East Asia are already leveraging these technologies to contribute to sustainable natural resource management through several different mechanisms. Some examples are described below:

Urban planning

1. Thailand: Geospatial platform for tracking and managing particle matter (PM2.5) using satellite imagery[15]

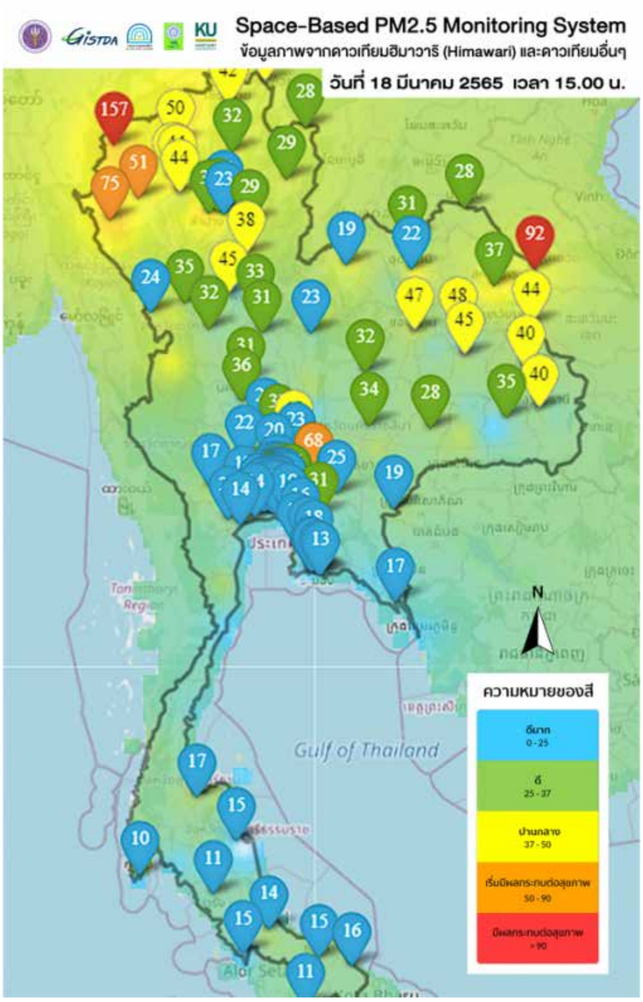


Thailand is bridging spatial data gaps to alleviate the impacts of particulate matter 2.5 (PM2.5). Such spatial data is crucial for identifying the source of emissions and estimating a holistic overview of PM2.5 levels, as well as distribution across the country.

The Space-Based PM2.5 Monitoring System[16] was developed by GISTDA in collaboration with government organizations and educational institutions. This project analyses satellite imagery, geospatial data, ground-based measurements and other PM2.5-related physical factors which are utilized to assess near-real time concentrations of surface-level PM2.5 at an hourly basis over Thailand.

The information on the platform is regularly processed using hourly aerosol data retrieved from Japan's Himawari 8 weather satellite, which is then further re-analysed with data from the Thai Meteorological Department weather stations. The information is displayed on an hourly basis for several locations across the country and can be accessed via an online web and mobile application. The web application displays the PM2.5 volume within five different categories, from very good to unhealthy. The data can be accessed from anywhere and at any time, making it easily accessible for both decision makers and the genal public. This project supports air pollution management both at policy and operational level (Figure 2.14).

Figure 2.14: Web application and mobile application of the PM2.5 tracking system using satellite imagery



GISTDA and others, "Space-Based PM2.5 Monitoring System", n.d. Available at http://pm25.gistda.or.th/pm25/ (accessed on 13 September 2022).

2. Phnom Penh, Cambodia: Application of Land Surface Temperature (LTS) analysis in Urban Green Spaces (UGS)

There is a high global need for more Urban Green Space (UGS) as it plays an important role in the sustainable development of cities. UGS, which includes parks, community gardens, roof top gardens, vertical gardens, meadows, woods and cemeteries, is on the policy agenda of many cities and is being integrated into urban city planning across the world. UGS contributes to the well-being of cities and their residents, bettering health, social cohesion and becoming a popular solution to combat the effects of urban heat island, particularly in tropical cities. For example, research undertaken in 2005, in Singapore, explored the severity of urban heat islands and cooling impacts of green areas at a macro-level. It was found that there was a strong correlation between the decrease in temperature and the appearance of large green areas throughout the city.[17]

The project, Build4People: Enhancing Quality of Life through Sustainable Urban Transformation in Cambodia, aims to research and promote sustainable building and urban development practices within Cambodia. This people-centred, urban development project tackles all aspects of urban development, including impacts on climate, increasing green space, sustainability in the construction of neighbourhoods and buildings, and inducing behavioural change.

Throughout this project, Landsat 8 data was used to undertake a Land Surface Temperature (LST), and a Normalized Difference Vegetation Index (NDVI) analysis. Research undertaken assessed the correlation between the LST and NDVI analysis to understand the urban heat island scenario within Phnom Penh, Cambodia. The amount of green spaces can be also assessed by overlaying NDVI analysis with LST analysis. Such analysis helps to identify green spaces and areas with more surface temperatures.

Furthermore, such analysis also helps prioritize and determine administrative areas for UGS according to both the area coverage and the percentage coverage of maximum LST within the boundaries of administrative units. The results will help relevant stakeholders and governments in planning and decision-making regarding the management of UGS.

Waste management

3. ASEAN cities: Monitoring plastic waste

Over 11 million tons of plastic waste enters the oceans every year, and Asia-Pacific countries contribute to over half of land-based sources of marine plastic pollution. In the region, rapidly expanding cities with underdeveloped waste management systems are to blame for as much as 60 per cent of plastic waste leakage into the environment.

In 2020, ESCAP, in partnership with the Government of Japan, launched the 'Closing the Loop' project, which aims to reduce the environmental impact of cities in South-East Asia, by addressing plastic waste pollution in rivers and oceans.[18] Four pilot cities in Indonesia, Malaysia, Thailand, and Viet Nam were chosen to monitor and measure plastic waste using digital innovations and powerful algorithms trained by artificial intelligence (AI).

Satellite imagery was also combined with ground sensors and meta data from a range of data sources to detect ocean-bound plastic pollution. Once the hotspots were identified, the four pilot cities were supported to develop strategic action plans to develop strategies and prioritize investments accordingly.

In addition, this project provided training through online eLearning courses for policymakers and decision makers to gain knowledge on land-based plastic waste pollution issues. It also provided a platform to share new scientific knowledge and methodologies, explore innovative technologies to measure and monitor plastic waste and build strategies that apply a 'circular economy' approach in managing plastic waste streams.

The course is designed to share the latest knowledge and approaches to measuring and managing marine plastic pollution from land-based sources for the achievement of local, national and regional goals related to sustainable development. This project supported the implementation of Sustainable Development Goals 11, 12 and 14 (Figure 2.16).

CLOSING THE LOOP

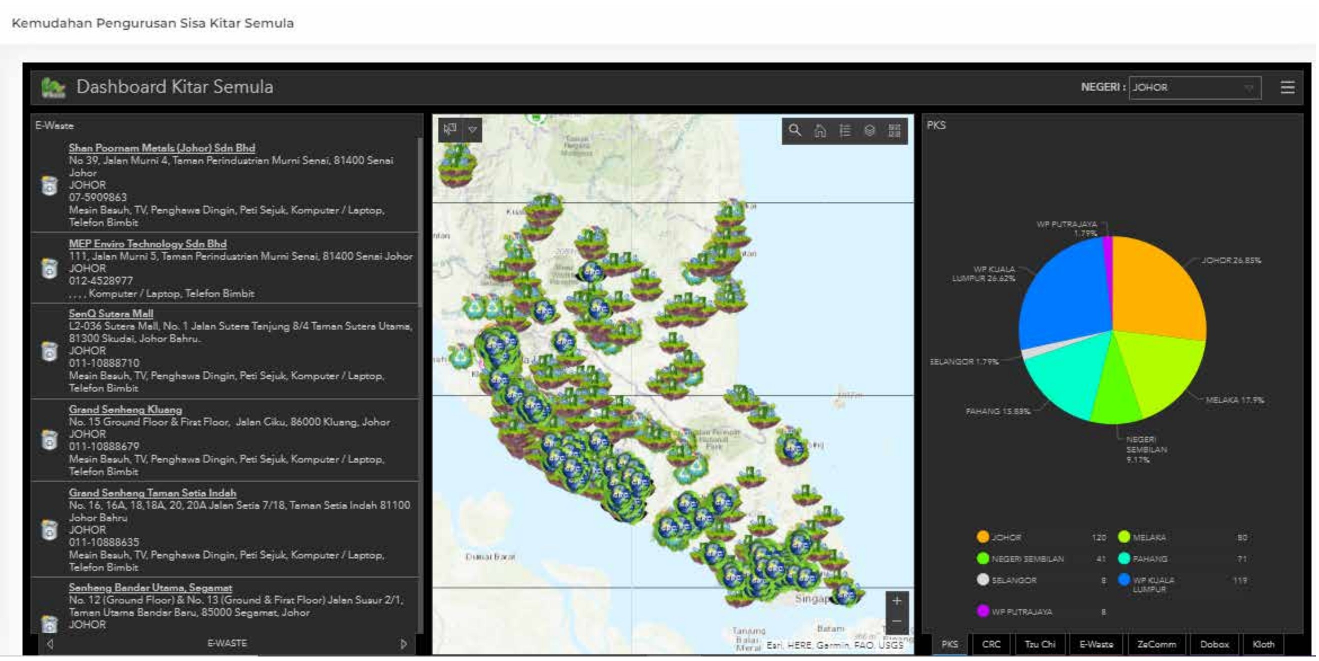
4. Malaysia: Driving resilient and sustainable waste management[19]

As Malaysia's population grows, innovative new approaches to waste management are required to ensure communities are resilient and sustainable. Rising to the challenge, the Solid Waste and Public Cleansing Management Corporation (SWCorp) developed a technical solution that enables more cost-effective and environmentally friendly waste management practices.

The solution uses advanced geospatial applications to create a near real time interactive view of the entire waste management network. The Waste Executive Geographic Information System (WEGIS) is an application designed to enhance SWCorp's productivity by providing instant access to high levels of data and information for staff. This portal combines all data and information, making it easy for staff to access data anywhere, anytime (Figure 2.15).

By digitally transforming the previously manual paper-based process, the organization has been able to significantly increase efficiencies and improve customer service. Since the programme's inception in (2018), the total collection of recycled items recorded by SWCrop has increased by 89 per cent between May 2020 and May 2021.[20] This demonstrates that through the innovative use of geospatial applications and big data, governments are able to increase their sustainable waste management efforts and contribute to achieving clean, green cities.

Figure 2.15: **Waste Executive Group Information System (WEGIS) portal**



Source: National EnvSource: ESRI Malaysia, "SWCorp embraces digital transformation to reach 40% recycling target by 2025", 6 April 2022. Available at: https://esrimalaysia.com.my/news/swcorp-embraces-digital-transformation-reach-40-recycling-target-2025

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Land use changes and forest management

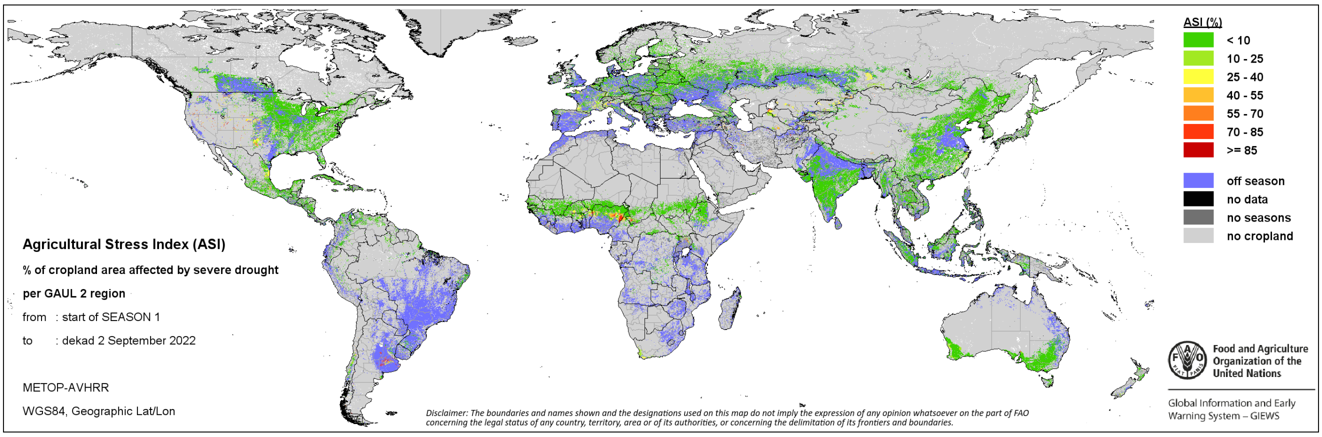
5. Agricultural Stress Index System (ASIS)

To address the lack of sufficient ground meteorological data for global drought monitoring, the Food and Agricultural Organization (FAO) developed the Agricultural Stress Index System (ASIS),[21] together with the Flemish Institute for Technological Research (VITO) and the Joint Research Centre of the European Commission. The ASIS uses satellite-based, aggregated vegetation health information based on the administrative units of each country for ease in decision-making. The ASIS strategy first proved to be a viable drought monitoring tool for Africa, through its capability in identifying major drought events across the continent (Figure 2.16).

Crop masks, cropping seasons, and crop coefficients are applied to produce ASIS drought maps and statistics. By integrating country-specific crop masks and national crop statistics, country-level ASIS can be utilized by regional offices to identify agricultural lands experiencing high likelihood of water stress. The country-level ASIS is based on the 10-day Vegetation Health Index (VHI) at 1 km spatial resolution. This 10-day update period allows for close monitoring of drought signals so the local government can act accordingly.

The data, available through the online web portal and platform, is made available for countries to utilize and integrate within their own national systems and plans. Such up-to-date data and information can help countries monitor and plan their agricultural activities.

Figure 2.16: Agricultural Stress Index during August 2022



Source: Food and Agriculture Organization of the United Nations (FAO), "Earth Observation", 1 September 2022. Available at https://www.fao.org/giews/earthobservation/index.jsp?lang=en

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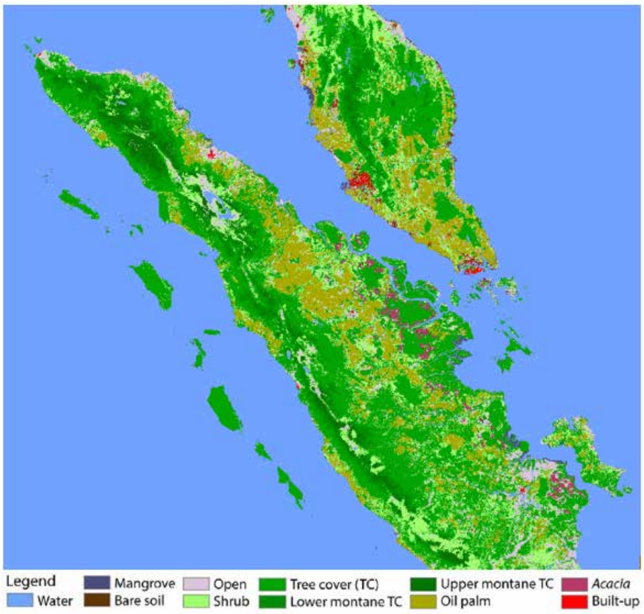
6. Singapore: Regional Land Cover Mapping and Land Cover Change Studies

Land cover change, especially the conversion of forest to other land use, has been implicated as an important contributor of carbon emissions. Deforestation, taking place on organic peat soil, is considerably more damaging for the environment due to very high carbon emissions related to the drainage of peatlands. Land cover change, in the region, is also intimately connected to land and forest fires, as fires are a convenient mean for land clearing. The Centre for Remote Imaging, Sensing and Processing (CRISP), at the National University of Singapore (NUS), formed a land cover research group to engage in climate change and environment-related research. The highlight from their research was two land cover maps at 250 metre resolution of the insular region of South-East Asia, for year 2000 and 2010, generated with MODIS and other supplement data, including ALOS L-band SAR data. From these two land cover maps, the deforestation rate for various forest types, especially peat swamp forest, were estimated. Another regional land cover map at 250 metre resolution for the whole South-East Asia region (including the continental SEA), for 2015, was subsequently produced using MODIS data. The use of Google Earth-Engine Pro (now free of charge) helped to accelerate the progress of the project. The group had also generated a peatland change map with higher resolution SPOT data.

The earlier land cover maps were composed using semi-automated approaches with a combination of unsupervised clustering and visual interpretation. The analysis was based on cloud-free image composites built by combining half a year of daily observations of the surface reflectance by MODIS on Terra and Aqua satellites. As the volume of 10-30 metre resolution data increased rapidly over the 2010s, fully automated processing and classification approaches were developed for high resolution land cover mapping in South-East Asian conditions. The lessons learned from the visual land cover classification were incorporated into automated decision tree classification approaches. The complicated decision trees utilized band and index thresholds of optical and radar datasets, in combination with auxiliary datasets. Implementation of the decision trees in cloud processing platforms allowed processing of high volumes of satellite and auxiliary data without the need to download them to CRISP computers. Recently, the group had started to focus on developing machine learning (artificial intelligence) models for automatic land cover mapping (Figure 2.17).

Figure 2.17: 30m land cover map for 2020, over Sumatra and Peninsular Malaysia, generated by Machine Learning classifier



Source: Submitted by Singapore, in response to the questionnaire of the ESCAP secretariat.

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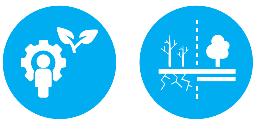
7. Philippines: The Multispectral Unit for Land Assessment (MULA)[22]



The Philippines is faced with many pressing environmental issues, which have implications for the country's economic and social sectors. Satellite technologies can help ensure sustainable use of natural resources and help develop more effective disaster management and response.

The MULA satellite is the Philippines' flagship Earth observation satellite project. This project aims to continue the operation of a sovereign satellite for the Philippines based on a medium resolution Earth observation platform, building on the gains from experimental and technology demonstration-oriented satellites built in the past. The key operational features of the MULA satellite include its wide area coverage of up to 127,000 km^2 daily, simultaneous capture and download for near-real time availability of data, and the capability to capture 5-meter resolution images at nine different bands suited for wider applications in agriculture, environment, resource management, disaster, and security, among others.

8. Malaysia: Utilization of remote-sensing technology for deforestation identification

Deforestation continues to be a problem across the Asia-Pacific region, with many countries experiencing rapid land use change due to urbanization. Furthermore, climate change is accelerating environmental degradation, making it crucial that tropical forests are used more sustainably.

Malaysian researchers have presented an overview of how remote-sensing data, coupled with additional supporting data, can be used for mapping quantity changes of tropical forests in Malaysia. The analysis used open source satellite imagery from the Landsat programme, which hosts an array of archive imagery dating back to the 1970s. Due to Malaysia's tropical climate, obtaining cloud-free imagery was a challenge. However, with the vast archive of imagery available through the Landsat programme, seamless mosaics were acquired between 2005 and 2020, and were successful in producing a quality imagery mosaic of Malaysian forests.

These outputs were used to identify forest locations, through remote sensing image classification, and then classified into three major types: dry-inland forest; peat swamp; and mangroves. Additional geospatial methodologies, such as post-classification change detection methods, were also used to determine areas that had undergone land-use conversions from forests to other land-use types, in order to identify possible deforestation.

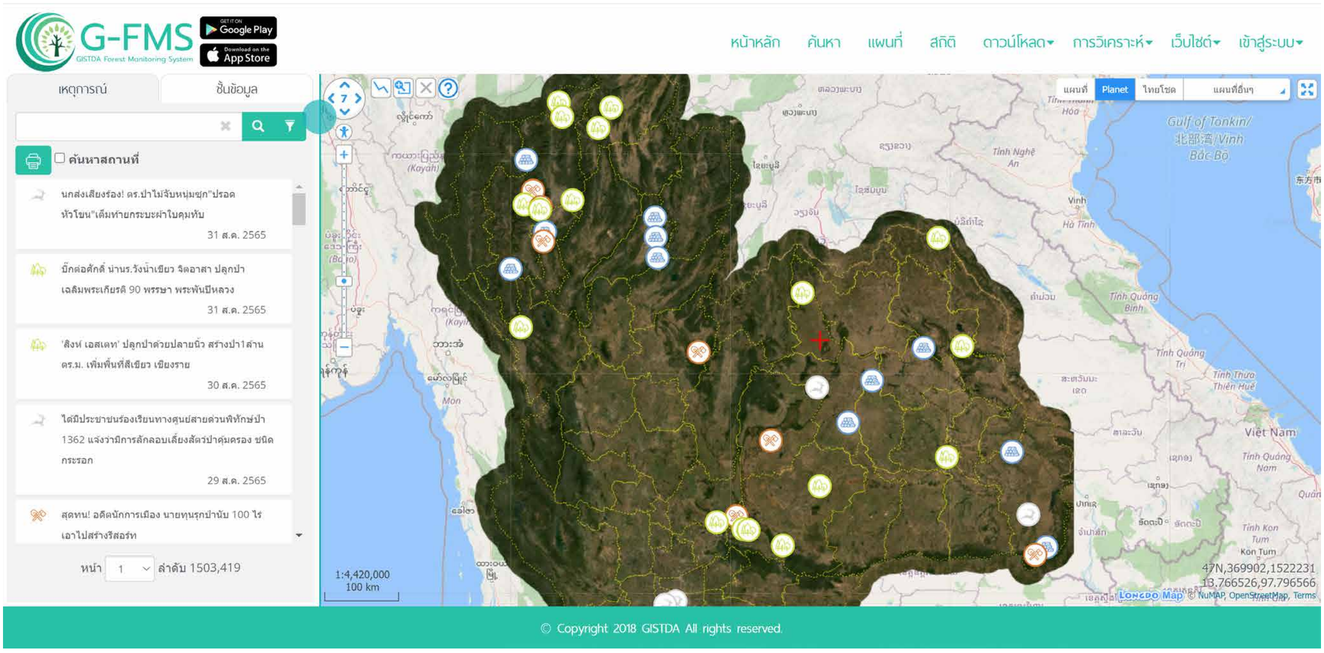
This study found that the use of historic satellite imagery can be used to monitor deforestation over tropical regions, identifying and highlighting areas of concern for government agencies and ministries to use for further decision-making and action. The research demonstrates the potential of satellite imagery to inform carbon offset programmes and prevent planned deforestation through improved management practices. Satellite imagery gives the potential for decision makers to track changes within forests over time using methods such as change detection and land classification. Such methods will produce outputs that can be leveraged by decision makers to help in forest management and prevent deforestation across wetlands.[23]

9. Thailand: Forest Resource Monitoring System to identify suspected deforestation[24]

The Geo-Informatics and Space Technology Development Agency (GISTDA) has developed an online forest monitoring system, G-FMS (GISTDA Forest Monitoring System), which is updated regularly and available in both a web and mobile application for easy access to users (Figure 2.18). The platform uses geospatial data to monitor deforestation, forest encroachment, illegal logging and forest fires. Such an information system enables the precise analysis of forest encroachment zones, aids in identifying target areas, expedites delivery of this information to the target area, and supports the efforts of local officials to effectively prevent further degradation of forests.

The monitoring system may also be used to predict the likelihood and occurrence of those future events that require concerned organizations to plan for the collection of signals, and interpret satellite data in regions prone to accidents. In addition to regaining the forest area, the natural state of the resource will be preserved which is in alignment with the objectives of national and global policy agendas. Indeed, deforestation poses a significant environmental threat that has implications for quality of life and contributes towards climate change.

Figure 2.18: G-FMS platform



Source: G-FMS Platform. Available at https://gfms.gistda.or.th/map (accessed on 13 September 2022).

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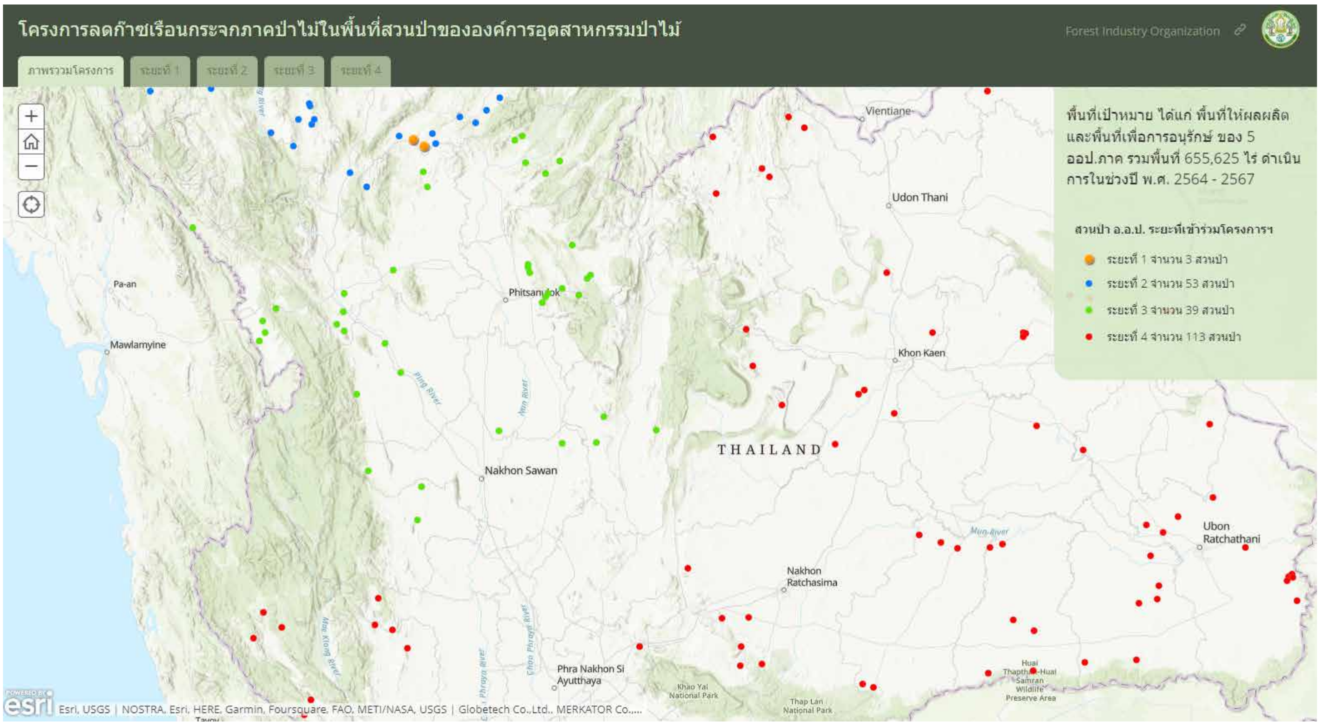
10. Thailand: Forest Industry Organization Geospatial Information Portal[25]

The Royal Forest Department in Thailand has launched the Forest Industry Organization Geospatial Information portal to display geospatial and remote sensing analysis in an online web mapping application. This online application can be shared any time, making the use of applications suitable for various tasks, such as field data collection and online data visualization.

The portal uses satellite and aerial imagery together with ground survey validation to investigate and assess the condition of existing forest areas, including land-use classification and mapping of plantations. Research has also been undertaken on the use of satellite data and information to identify carbon credits in plantations within the forest sector, as well as to reduce greenhouse gas emissions (Figure 2.19).

Figure 2.19: Greenhouse gas reduction project in forest plantation



Source: Royal Forest Department, Thailand. Available at https://gisportal.fio.co.th/portal/apps/MapSeries/index.html?appid=03fbb4af53df4782a01ccf82ea7df46d (accessed on 13 September 2022).

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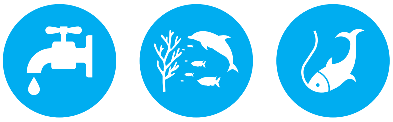
Water resource management

11. Philippines: Aquatic ecosystems and water resources management[26]



Numerous initiatives on aquatic ecosystems and water resources management have been implemented by academic research institutions within the Philippines. The Integrated Assessment and Modelling of Blue Carbon Ecosystems for Conservation and Adaptive Management (IAMBlueCECAM) utilizes space technology and geosimulation to assess vegetation dynamics, such as in seagrass meadows, mangroves, and the rest of the blue carbon ecosystems. The data/methods used are LiDAR, Hyperspectral, Sonar Remote Sensing, and web GIS for the mapping and geosimulation of these blue carbon ecosystems. Other noteworthy developments are the studies conducted by the University of the Philippines on coral reef visualization and assessment (and the rapid reef assessment system). The Department of Science and Technology leads the funding of these initiatives, alongside collaborations with local government units, other state universities, the Department of Environment and Natural Resources, and the Department of Energy.

The management of aquatic ecosystems and water resources is a top priority in the coming decade. The investigation of changes in seascapes that affect human and ecological security is particularly important as these affect sustainability, and the spatial-temporal detection of vegetation change in intact, restored and disturbed mangroves. Such changes, triggered due to climate, also impact the sustainability and stability of the supply of food for fish. In this regard, numerous initiatives and projects will continue to be implemented by academic and research institutes within the country. PhilSA will also continue to provide the necessary data, products and solutions related to sea surface temperature anomaly (SSTA) to various stakeholders so they can address the challenges.

IAMBlueCECAM

This program produced inventories of mangrove forests and seagrass habitats using space technology and geosimulation. An online community-based tool for assessing local blue carbon presence was developed in addition to maps of blue carbon ecosystem zonation. The program covers the area of coastal ecosystems of Coron, Busuanga and Puerto Princesa in Palawan, Ibajay, Batan, and Kalibo in Aklan and Banate Bay in Iloilo.

IAMBlueCECAM produced an accurate and detailed inventory of mangrove forests and seagrass habitats in selected pilot sites using remotely-sensed data and ground-based measurements as one of its major outputs. In addition to the extent of mangrove forests and seagrass habitats, blue carbon ecosystem zonation, species composition and above-ground biomass were mapped using methodologies developed by the program. The maps and other outputs can provide local officials with information on the extent of the mangroves and the species present in the area for conservation purposes and effective management.

The Operationalization of Environmental and Resource Mapping (OpERA)

Applications (OpERA) Project is a national research and mapping initiative on environmental pollution and natural resources of PhilSA. The project monitors natural resources and the condition of air and water quality through integrated satellite-derived and ground-based data and provides comprehensive information in support of sustainable decision-making, management, and conservation. Currently, research is being conducted on the deep-learning methods in mangrove mapping. Other initiatives include benthic habitat and water quality mapping. Coastline detection is also being conducted to monitor progression of reclamation and other coastal activities. The target beneficiaries of this project consist of various government institutions, and non-governmental organizations whose work centres on the environment, remote sensing, and data analytics. This project is under PhilSA's larger flagship program on Space Data Mobilization.

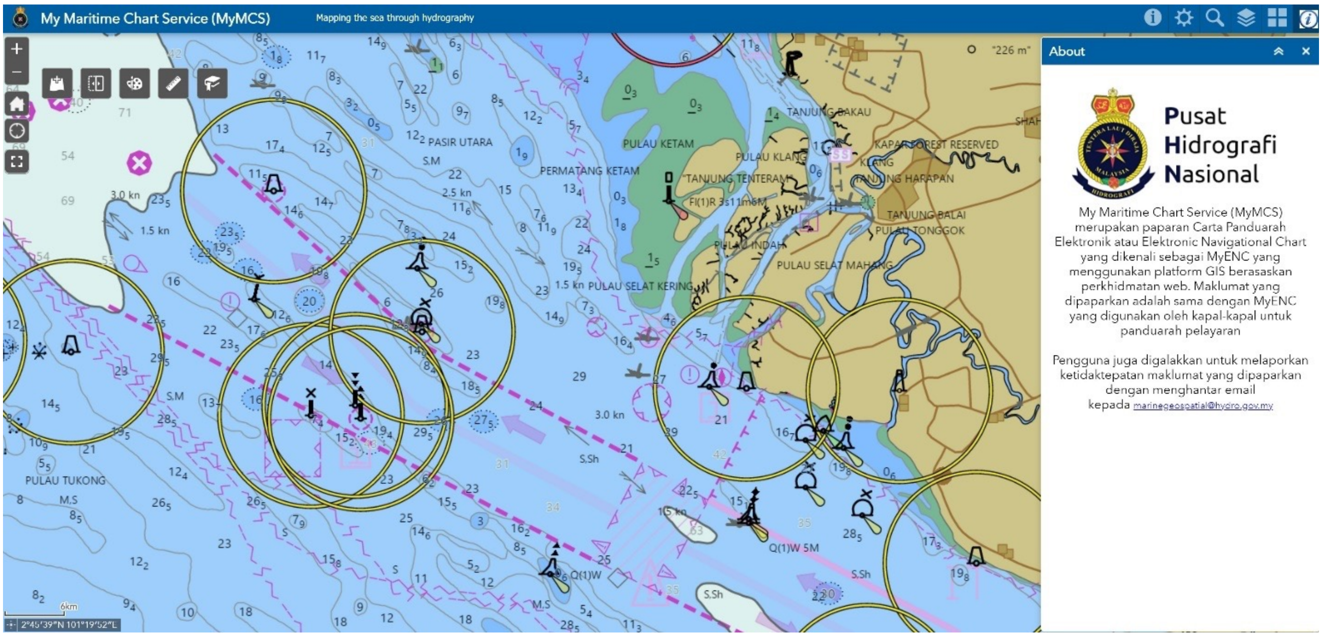
Marine ecosystems and sustainable fisheries

12. Malaysia: MyMarine GeoHub - Innovative Marine Spatial Data Infrastructure portal[27]

In 2021, the Royal Malaysian Navy's National Hydrographic Centre deployed a digital solution to create a Marine Spatial Data Infrastructure portal as a central gateway to the country's marine information. The MyMarine GeoHub combines data and products in a single application, sharing key data and optimizing workflows across the maritime sector (Figure 2.20). This application will lead to greater collaboration, meaning that stakeholders in the public and private sector can rely on actionable insights to optimize ocean use, manage offshore infrastructure and ensure safer navigation and streamlined vessel traffic management.

The hub also provides a better understanding of Malaysia's coastlines and the ability to predict areas that are most likely to be impacted by climate change. Combining these vital elements means that Malaysian coastal communities will be more resilient and its waters safe, secure and sustainable. MyMarine GeoHub is the central resource for marine spatial information for improving the conservation of marine wildlife habitats or informing climate resilient strategies.

Figure 2.20: MyMarine Geohub platform



Source: ESRI Malaysia, "Go behind the scenes of Royal Malaysian Navy's (RMN) National Hydrographic Centre (NHC) award-winning marine spatial data portal – MyMarine GeoHub- and learn how sharing accurate and timely data supported #OpBenteng", Twitter, 27 May 2021a. Available at https://mobile.twitter.com/esrimalaysia/status/1397704138151055364/photo/1

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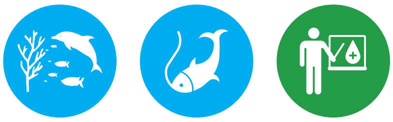
13. Singapore: GeoSpace-Sea – The National Marine Spatial Data Infrastructure[28]



Singapore is the maritime gateway to Asia, particularly due to its continued efforts towards building a sustainable marine space for Singapore. The Maritime and Port Authority of Singapore has collaborated with 11 other government agencies and institutes to develop the GeoSpace-Sea platform.

The GeoSpace-Sea platform is a Marine Spatial Data Infrastructure which will provide a comprehensive and consolidated database of various marine and coastal data, including port, marine and coastal planning data.

The platform will allow users to discover Singapore's marine data infrastructure through various web-based applications that will be important access points for users to view data in 2D and 3D form. This data can be used for planning, monitoring, decision-making and operational needs. It will open up possibilities of enabling various applications and generating marine knowledge, such as marine and coastal spatial planning, marine science research and development, climate change adaption, marine conservation and disaster response.

Having marine geospatial data on where people reside, what activities they engage in, and their influence on the marine environment will aid decision makers in implementing more sustainable methods. High-quality and trustworthy land-sea navigational and seabed data enables more effective transportation routes, improved fuel efficiency and port design, all of which can assist in reducing the carbon impact of transportation. Therefore, streamlining a country's maritime infrastructure is a critical tool not only for decision makers and stakeholders, but also to help the public respond more effectively to challenges, such as climate change and maritime disasters (Figure 2.21).

Figure 2.21: GeoSpace-Sea portal

Source: GeoSpace-Sea Portal. Available at https://esrisingapore.com.sg/news/mpa-and-esri-singapore-take-singapores-marine-landscape-new-depths (accessed on 13 September 2022).

14. Thailand: Geospatial information for sustainable fisheries resources management[29]

In Thailand, the Department of Fisheries (DOF), under the Ministry of Agricultural and Cooperatives (MOAC), is responsible for managing fishery resources sustainably for better food security. This is being undertaken by promoting and encouraging an increase in aquaculture production throughout the whole supply chain, and regulating and controlling fishery resources for sustainable utilization and maintenance of diversity.

Geospatial information has long played an important role in such sustainable fisheries management, covering inland, coastal, and marine areas, even beyond the Thailand Exclusive Economic Zone (EEZ). Spatial measurement mapping, monitoring, and modelling of aquaculture and fisheries has also been achieved by using space applications and geospatial data. The DOF has developed an online Fisheries GIS portal, which is used to manage and monitor fisheries, and conserve and maintain the abundance and biodiversity of natural resources. This geospatial data management system operates in a private cloud (Server Department of Fisheries) and can be used to manage spatial data within the organization, including assigning permissions to staff to access, analyse and share information via a web browser, smartphone, tablet or desktop computer.

This data system hosts an array of data on aquaculture, including a site suitability map at a scale of 1:50,000 for aquaculture development for the whole country, and all the current distribution and attributes of registered farms and farmers (approximately 520,000 farmers) together with their culturing activities. Currently, the production forecast model for shrimp is being developed to be used for better planning and management of the entire value chain of shrimp products for domestic consumption and export. Furthermore, this spatial database will also be used for shrimp disease monitoring which will enable disaster early warning, allowing for mitigation by and compensation to the farmers.

In addition to aquaculture application, Thailand has applied communication satellite technology with advanced spatial analysis tools in GIS as a key technology in developing a system called Vessel Monitoring System (VMS) for monitoring Thai-Flagged Fishing Vessels activities (approximately 5,200 vessels) in and beyond Thai waters. The VMS has been operated continuously by the DOF Fishery Monitoring Center (FMC), since 2016, to combat illegal, unreported, and unregulated fishing (IUU Fishing).

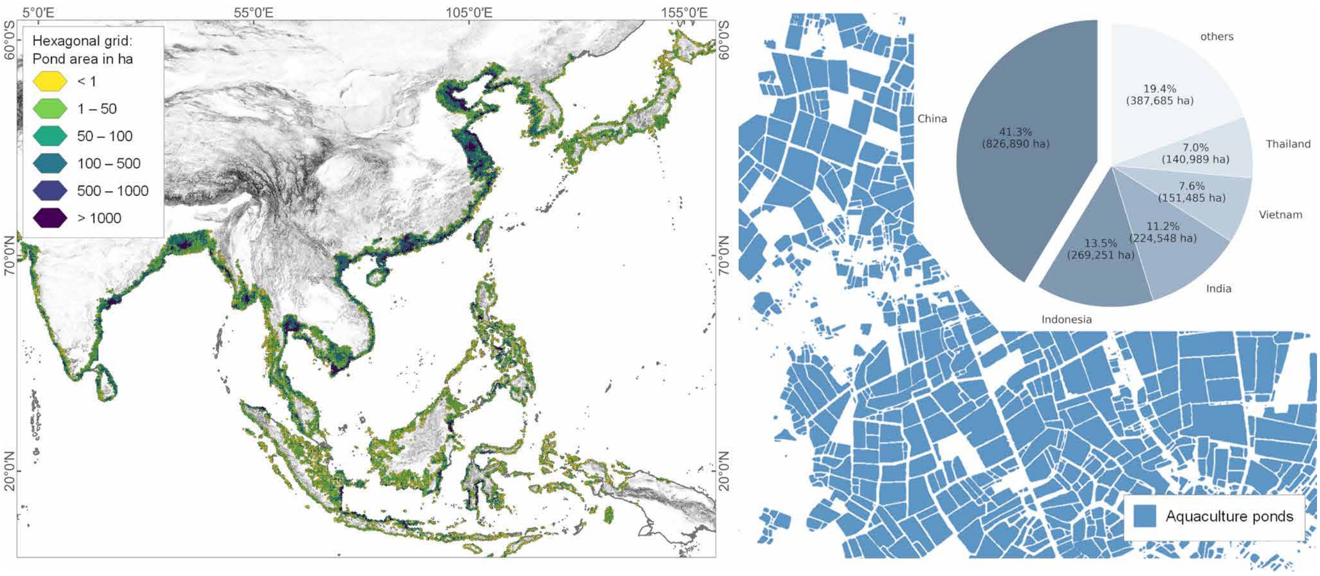
15. Hotspot analysis of coastal aquaculture

A growing global population requires an expanding food source; aquaculture meets much of this need in South-East Asia, where fish, shrimp, and molluscs are an important staple in many South-East Asian diets.[30] This makes the aquaculture industry of high socioeconomic value within the region. However, land reclamation, creation of ponds and the associated waste products can lead to severe environmental degradation. Mapping aquaculture footprints at regional, national, and local administrative-unit scales can provide fundamental information for the management and sustainable development of coastal ecosystems.

To map the patterns, trends, and production hotspots of coastal aquaculture across the entire South-East Asian coastal zone, Earth observations from a time series of high-spatial-resolution synthetic aperture radar (SAR), and optical satellite data from the Copernicus Sentinel missions was integrated with time-series information from national catch fisheries and aquaculture statistics. Using open-source data and machine learning, an automated extraction workflow that utilized high-performance cloud computing infrastructures was developed that assessed and analysed areas of aquaculture.

The results of this workflow captured attributes of more than 20,000 km^2 of mapped aquaculture ponds across the area, then divided the data into national, state/province/equivalent, and district/county/equivalent levels. Such machine learning-based methodology enabled the detection and mapping of coastal aquaculture at the single-pond level for a continental scale (Figure 2.22). The information, provided to spatial planners and policymakers, facilitates sustainable development and ecosystem management in the coastal zone, which is key to ensuring food security.[31]

Figure 2.22: **Mapping of coastal aquaculture at the single-pond level, area in ha**



Source: Marco Ottinger, and others, "Mapping Aquaculture Ponds for the Coastal Zone of Asia with Sentinel-1 and Sentinel-2 Time Series", Remote Sensing, vol. 14, No. 1. December 2022. Available at https://www.mdpi.com/2072-4292/14/1/153 (accessed on 13 September 2022).

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Theme 3 - Connectivity for the 2030 Agenda for Sustainable Development

Seamless connectivity across transport, information and communication technologies, and trade sectors is a key theme highlighted under the Regional Road Map and the Plan of Action. While Internet access is high across the region, there is also a widening digital divide. Geospatial information and tools can support member States in improving regional connectivity through capacity development opportunities and building smart digital systems.

The COVID-19 pandemic has driven many member States to accelerate mass digital adoption at an unprecedented speed and scale. However, at the same time the pandemic has widened and deepened the digital divide both between and within countries. This has reinforced a vicious cycle of economic inequalities, and further differentiated leading countries from the lesser developed, since digital dividends were not equally distributed.[32]

While some countries across South-East Asia are making progress towards bridging the digital divide, others are still falling behind. Some examples, from across the region, that show good practices and progress made towards enhancing connectivity are described below:

Transport and traffic systems

1. Cambodia: Geospatial modelling for emergency service road access to rural areas

Flood events seriously impact transport networks. Such disruptions then impact access to health care, education, and work, and limit opportunities for economic growth. The COVID-19 pandemic particularly highlights the need for connectivity, especially in terms of rural access to emergency health care, medicines, and food supplies.

In a working paper published by the World Bank, researchers provided a method for quantifying the effects of flooding on access to hospitals and other critical facilities.[33] It was found that it would take more than one hour to reach an emergency health centre for 37 per cent of people in the three rural Cambodian provinces studied. In the case of flooding, 27 per cent of people lost all access, and 18 per cent of the population experienced an increase of half an hour of travel time. These results were found through creating a geospatial accessibility model on the transport networks of rural areas and then applying climate resilience analysis to the model in order to intersect flood maps with the networks.

The results of the research demonstrate an evidence-based approach for prioritizing rural transport, road improvement and demonstrate clear benefits of rural infrastructure investments.

2. Selangor Malaysia: Collecting data for smart decision-making

Cities can leverage innovative digital technologies to improve quality of life of citizens by implementing smart city initiatives, such as developing safe environments, and increasing economic opportunities. In Malaysia, the federal government launched the Malaysia Smart City Framework, in 2019, to serve as a guide for local authorities. This framework resulted in several Malaysian states (Sarawak, Selangor, Penang and Johor) embarking on their own smart city plans.

The Smart Selangor Delivery Unit (SSDU) was established in 2016 to make Selangor a more liveable smart state by 2025. The blueprint focuses on four areas: smart government, economy, digital infrastructure and community. The plan focuses on the use of digital technologies, such as geospatial data and space applications, to deliver on several initiatives. Some of these include:

- An intelligent traffic monitoring system, in Subang Jaya, that monitors the main arterial roads;
- The Selangor Intelligent Transport System (SITS), which is an app that tracks Smart Selangor buses;
- 14 smart bus stops equipped with WiFi and CCTV cameras;
- The Smart Selangor Data Centre and Selangor Gigabit Network;
- The SITS app to use the Smart Selangor buses, where citizens can use the app to see the arrival times of buses. The authorities can use the app to monitor whether the buses are punctual and following the correct route;
- Waze App partnership where users can report potholes and road damages to authorities through the application for immediate road fixing.

Through technologies like remote sensing and big data analytics, governments can use more anticipatory or scenario-based approaches to support evidence-based decision-making.

3. Singapore: Traffic Watch makes use of spatial data to tackle road congestion[34]

The Singapore Land Transport Authority (LTA) has created the Singapore Traffic Watch system, using a combination of real-time data and historical analysis to provide insights to help manage traffic. The system uses sensors to gather information on the real-time location of buses and their arrival times at various stops to improve transport planning.

The LTA has also been collecting anonymized data from commuters' fare cards to help identify frequent commuter locations, which enables them to better manage bus fleets and commuter demand. As a result of this data collection and analysis, the LTA has seen improvements on several fronts. Results show a 92 per cent reduction in the number of bus services with crowding issues, despite a year-on-year increase in average daily bus ridership and a 3 to7 minute reduction in the average waiting time on popular bus services. It pulls data from LTA's Land Transport DataMall and weather service, providing analytical charts that plot current traffic conditions against past trends. Their real-time map allows the users explore how the different data sources can help to explain congestion and other traffic situations (Figure 2.23).

Figure 2.23: Singapore Traffic Watch

Source: Smart Nation Singapore, "Open Data and Analytics for Urban Transportation, n.d. Available at https://www.smartnation.gov.sg/initiatives/transport/open-data-analytics. (accessed on 28 September 2022).

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

Access to the Internet and digital technologies

4. Philippines: Free public Internet access programme[35]

The Philippines is transitioning from the traditional Internet service to receiving its Internet connectivity via satellite technology. The Philippine's 2017 National Broadband Plan, which aims "to accelerate the deployment of fibre optic cables and wireless technologies to improve Internet speed", takes advantage of satellites and other emerging technologies for broadband access provision and deployment in the countryside.[36]

The Free Wi-Fi for All – Free Public Internet Access Program, or Free Wi-Fi for All Program, is a program of the Philippine Government's Department of Information and Communications Technology's (DICT) that aims to provide people with access to opportunities, education, and information, and the ability to participate in the growing digital economy through free Internet in public places nationwide.

The program provides free Internet access to the general public through the installation of Wi-Fi access points to publicly-owned premises. It aims to establish Wi-Fi access points to a total of 1,634 localities spanning 1,489 from first to sixth class municipalities and 145 cities with 13,024 sites covered by 18 Points of Presence across the Philippines. According to the DICT, as of 10 November 2021, a total of 11,475 free Wi-Fi facilities were already operational in various municipalities, cities and provinces nationwide. Since the covered sites are mostly located in geographically isolated and disadvantaged areas, including remote or far-flung areas, the implementation leverages use of satellite communications technology, particularly very small aperture terminals, to connect such areas to the Internet.[37]

5. Viet Nam: Building the country's largest data centre[38]

Viet Nam's state-run telecommunications group, Viettel, recently announced a plan to build the largest data centre in Viet Nam with a total investment of VND 6,000 billion (approximately US$ 261 million). The project will be invested in the Hoc Mon and Cu Chi districts of Ho Chi Minh City. Under the project, Viettel will work alongside the two districts to promote the digital transformation of infrastructure, governance, the economy and the overall society.

By 2025, the telecoms group aims to have invested in 4G and 5G infrastructure that covers broadband services for the entire population, and fibre optic infrastructure for every household. Regarding a digital government, Viettel will create and deploy smart-control centre services and a shared data centre system for administration operations.

According to a press release by the Ministry of Information and Communications, Viettel will help 100 per cent of businesses use digital management platforms, electronic contracts, and digital signatures. In terms of a digital society, the group will enable all residents of the Hoc Mon and Cu Chi districts to use smartphones and electronic payment accounts.

Most recently, a 5G network and an intelligent operations centre (IOC) were unveiled in the Mekong Delta province of Soc Trang. It will help public operations be more transparent, effective, and quicker, thus contributing to local smart city building and digital transformation.

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Box 2.1: Singapore: Singapore Space and Technology Limited (SSTL)

The SSTL, a non-profit non-governmental organization is mandated to promote awareness and adoption of space-related technologies and foster partnerships among various stakeholders to accelerate the high-tech ecosystem.

SSTL launched joint venture-building programs, Space Accelerator Programme and Project Cyclotron, in 2020 in connection with Cap Vista, an investment arm of the Defence Science and Technology Agency. Over 30 companies have been supported by SSTL's innovation programs in the first year since its launch. In addition to launching vehicles, remote sensing, communication satellites, low power electric propulsion, space robotics, global predictive space weather systems, and materials development for space radiation protection, these companies work on a wide range of space technologies and applications.

SSTL also focuses on Humanitarian Assistance and Disaster Relief (HADR). By using satellite and space technology sourced from companies and research institutions in Singapore, SSTL has augmented international partners' HADR efforts, such as the World Bank, the Changi Regional HADR Coordination Center (RHCC), the Red Cross and Airbus.

Theme 4 - Social Development

Social development is a cross-cutting issue for many SDGs, and despite high economic growth and significant progress in terms of poverty eradication, inequality persists in the Asia-Pacific region.[39] Space applications, particularly satellite imagery, can help support mapping activities such as mapping poverty, vulnerable groups, and identifying risk hotspots. Such mapping can help policymakers address vulnerabilities and further the development agenda in line with the Sustainable Development Goals.

Poverty including human poverty and income poverty

1. Indonesia: SDG monitoring

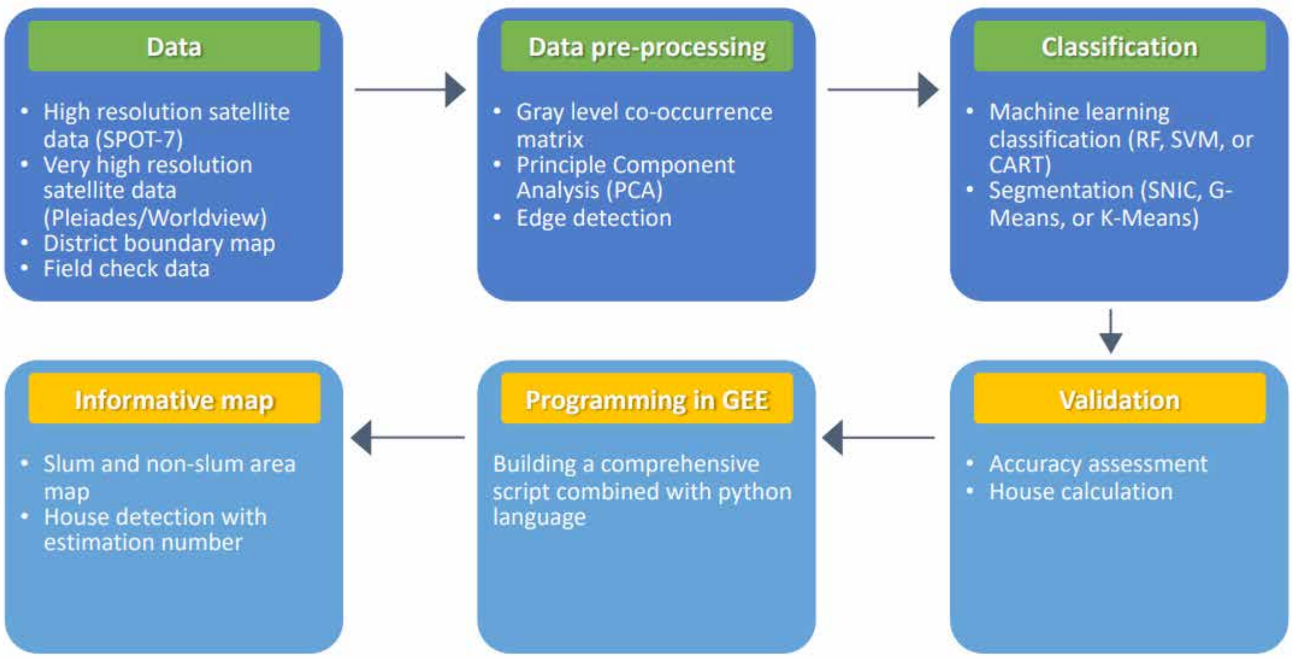
Efforts to promote geospatial information applications in local governments are increasing. The Governments of Indonesia and Thailand are using integrated spatio-temporal data to monitor progress in achieving the SDGs, with the technical assistance of experts from China and the Committee of Experts on Global Geospatial Information Management who are bringing in tools and lessons from their own experiences in Deqing, China.

In Indonesia, the pilot project supports the city of Makassar, South Sulawesi Province, and Bundung, West Java Province. In 2022 – 2023, both pilot cities will focus on mapping urban slum areas presented on the open access platform, which will support the estimated number of potential recipients that are eligible for the government's social assistance programme, as requested by the Ministry of Social Affairs.

Space applications, namely satellite imagery, will be used for mapping slums. This is done by identifying built-up areas and analysing them based on size, density and pattern of structure and layout. Slums and informal settlements are usually comprised of small, substandard building sizes, with high density structures, lacking public space within or in the vicinity of residential areas. The layout and pattern of these structures is usually disorderly and noncompliant with planning standards. These distinct features help analysts identify slum areas and informal settlements from formal/ planned settlements.

Through this project, Indonesia has developed different space-based methods to identify and classify slum areas within the country. The first method is the development of an online processing module, based on machine learning, to classify slum areas (case study was undertaken in Makassar City), and the second method uses applications of remote sensing data to identify slum areas for estimating the potential recipients of government social assistance (case study undertaken in Bandung) (Figure 2.24).

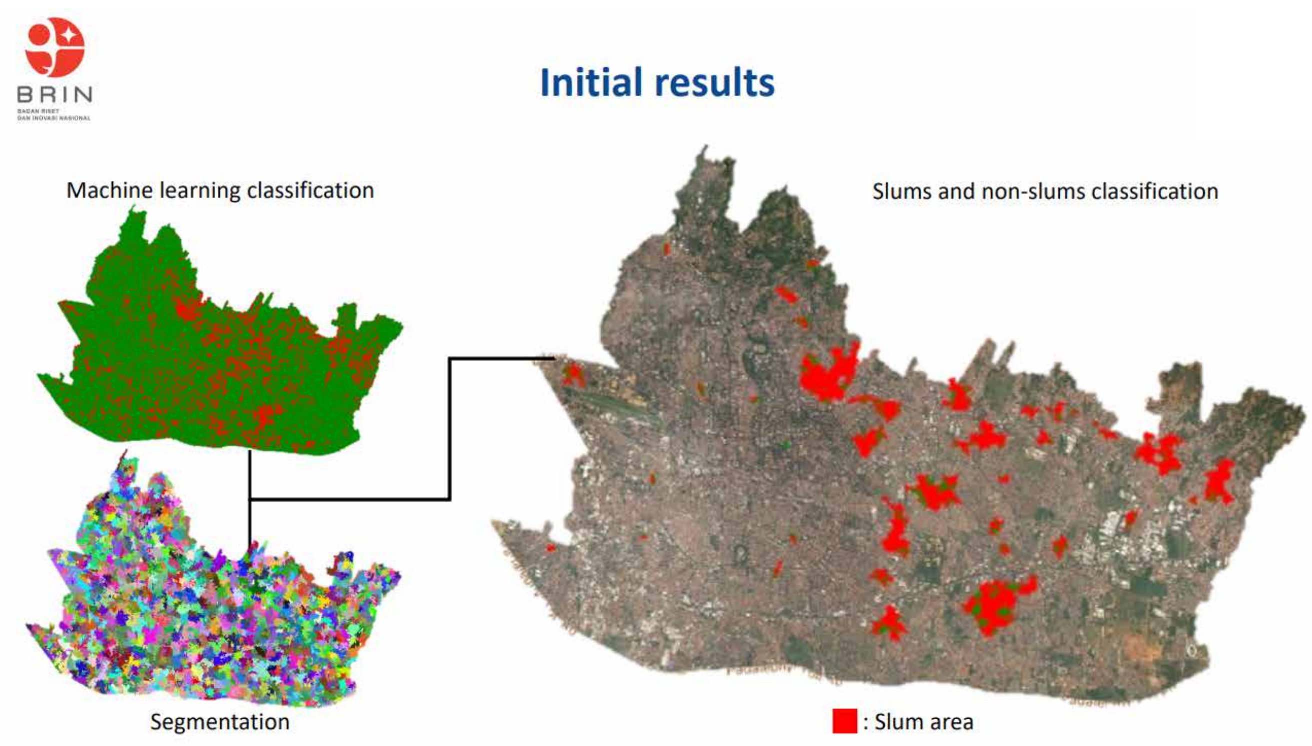
Figure 2.24: Data and methodology of Bandung city remote sensing data development mode to identify slum areas



Source: Orbita Roswintiarti, "Development of an open access-based operational platform to map slums in supporting the distribution of government social assistance program for potential recipients in Bandung, West Java Province, Indonesia and Makassar, South Sulawesi Province, Indonesia", Expert Advisory Meeting on Building Institutional Capacity for the Use of Integrated Spatio-Temporal Data in Local SDGs monitoring and decision making, Powerpoint presentation, 5-7 July 2022. Available at https://www.unescap.org/sites/default/d8files/event-documents/Development%20of%20an%20open%20access-based%20operational%20platform%20to%20map%20slums_Ms.%20Orbita%20Roswintiarti%20and%20Mr.%20Andi%20Ibrahim.pdf

The goal of these case studies is to optimize the use of remote sensing data to develop methods and models to identify slum areas and present the data on open access platforms. This will support stakeholders in decision-making, especially when it comes managing the distribution strategy of potential recipients of social assistance. Both of these case studies are new and are in the initial development of the classification model, with the final model development planned for January 2023 (Figure 2.25).

Figure 2.25: Results of the Bandung city output



Source: Oribta Roswintiarti, "Development of an open access-based operational platform to map slums in supporting the distribution of government social assistance program for potential recipients in Bandung, West Java Province, Indonesia and Makassar, South Sulawesi Province, Indonesia", Expert Advisory Meeting on Building Institutional Capacity for the Use of Integrated Spatio-Temporal Data in Local SDGs monitoring and decisionmaking, Powerpoint presentation, 5-7 July 2022. Available at https://www.unescap.org/sites/default/d8files/event-documents/Development%20of%20an%20open%20access-based%20operational%20platform%20to%20map%20slums_Ms.%20Orbita%20Roswintiarti%20and%20Mr.%20Andi%20Ibrahim.pdf

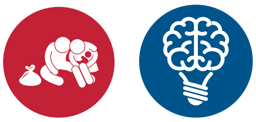
2. Thailand: Creating a database of low-income communities from aerial imagery

In Thailand, the Division of Geographic Information System (GIS) for Housing operates under the National Housing Authority, and is attached to Thailand's Ministry of Social Development and Human Security. The Division of GIS for Housing created a database for low-income communities to prepare housing development policies in compliance with the 20-year National Housing Development Strategy (2017–2036). The database covers the Bangkok Metropolitan Area and its vicinities, municipalities, and urban areas in provincial towns except those in the deep southern provinces of Thailand, namely Pattani, Yala, and Narathiwatare, which are excluded since conducting field surveys are unsafe. The database utilizes aerial photography and satellite imagery as the primary data type, with secondary data, such as location, community boundaries, and social, economic and environmental conditions, derived from field surveys.

Key elements from the images that are used to identify low-income communities are pattern, shape, and texture. The arrangement patterns of the low-income community are relatively unique: dense, disorganized, fragmented, narrow streets and walkways relative to the location of other landmarks, such as workplaces, temples, and roads. The shape of the low-income community boundaries is a massive gathering of buildings with no space around the buildings and smaller than usual size of houses. Rooftop materials, in the low-income communities, are mainly galvanized iron, which produces a clear reflection of the roof surface from the surrounding surfaces, which are mostly white or reddish-brown in colour. Field surveys validate the image interpretations by interviewing community leaders and households using a structured questionnaire, with the results being added to the database.

Creating this low-income community database for planning and development purposes can support SDG 11: Sustainable Cities and Communities, which aims to make cities and human settlements inclusive, safe, resilient and sustainable. This can be achieved by embracing change, planning for sustainable development, and helping low-income households achieve a better quality of life, in terms of their social, economic, environmental, and physical conditions.

3. Malaysia: An innovative humanitarian activities mapping[40]



Using space-based applications, specifically web GIS software, researchers in Malaysia have developed a web-based geospatial data platform which collects data and information on volunteering programmes in Malaysia. Many people, in Malaysia, are becoming more interested in volunteering with non-governmental organizations, however the data on where and what events are available are not managed adequately.

To overcome this problem, researchers have developed an online web-based geospatial data platform which provides basic information relating to the humanitarian programmes, and when volunteers are needed. This platform aims to connect users with volunteer organizations, streamlining the volunteer management tool for decision makers. To select an activity, a geospatial methodology is run, this consists of adding the data, running a query on volunteer selection, exporting the data, informing volunteers and recruiting them.

Once the platform was complete, beta testing was undertaken to understand users' needs and gain feedback. A survey was distributed to the public and potential volunteers, and the results showed that 93 per cent of the respondents agreed that there was a need to have a database and system for volunteers, specifically for mapping and storing data on volunteers, and tracking performance and calendar activities of volunteers.

4. Singapore: Innovation challenge to design device to better track location of people with special needs[41]

The Singapore Land Authority (SLA) and Singapore Space and Technology Limited have co-organized the "GNSS innovation challenge".[42] This challenge, occurring annually, aims to encourage teams of students to design autonomous delivery systems, using GNSS and SLA's Singapore Satellite Positioning Reference Network (SiReNT) technologies. It is hoped that, through this challenge, the teams develop wearable location tracking solutions that can more accurately track the location of individuals with dementia or special needs.

Current satellite technology, such as the Global Positioning Systems (GPS), has a margin of error of up to 10 metres. In 2021, the winning concept proposal of the Global Navigation Satellite System (GNSS) innovation challenge, "was a navigational tool using a high precision satellite positioning system to provide movement assistance and monitoring for the elderly and visually impaired. This navigational tool leverages precise GNSS technology provided by SLA's Singapore Satellite Positioning Reference Network (SiReNT) to provide outdoor and indoor movement assistance and monitoring to aid the visually impaired".[43]

With Singapore's increasing greying population, the development of such solutions can assist with caring for the elderly or those with special needs. This challenge is intended to engage young minds to overcome limitations in the development of wearable solutions to solve real-life problems that benefit the community. This initiative increased the interest of young people in the use of satellite positioning reference technology to power real-time, high precision positioning applications.

Box 2.2: ESCAP Statistics Division (ESCAP-SD): Geospatial Guides

The ESCAP-SD has developed guides that show how to process satellite data to produce maps and statistical tables, using the programmes QGIS and RStudio. The guides highlight features of geospatially-enabled programs and provide details of different types of open-source data as per users' needs. The guides help users to develop statistics in topics where geodata is useful. To date, the guides have shown how to map land cover change, assess the expansion of artificial surfaces and visualize population exposure to hazards. ESCAP-SD investigated the use of alternative data sources for tourism statistics during the COVID-19 pandemic for South-East Asian countries, namely Indonesia and Thailand. This study demonstrated the potential of web-scraped data, and satellite and geospatial data for producing tourism statistics. The data from web and satellites show similar trends to official tourism statistics calculated using traditional data sources such as surveys and customs forms.

Additionally, ESCAP-SD published several papers on the use of big data for official statistics within multiple statistical domains, including economic statistics, population and social statistics, environment and agriculture statistics, and for the sustainable development goals. The knowledge products outline examples of countries in Southeast Asia, such as Indonesia, Malaysia, Philippines, Thailand and Viet Nam, which are exploring the use of big data for official statistics.

The techniques shown in the instructional guides can be applied to areas of work where geodata and non-traditional sources of data can be useful. The guides also facilitate the implementation of the System of Environmental-Economic Accounting (SEEA).

Non-traditional data, such as web data and satellite data, have the potential to provide rapid estimates of change for immediate use by governments and other users. The methodology outlined in the guides can be used for topics where geodata is beneficial, for example, applying geodata for statistics.

Countries in the region are researching the use different big data sources to assess SDG indicators, and for producing official statistics. In some examples, statistical offices are exploring social media platforms, such as Facebook, YouTube and Instagram to conduct sentiment analysis.

Source: United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), "Big data for populations and social statistics", Stats Brief, No. 29, April 2021a. Available at https://www.unescap.org/sites/default/d8files/knowledge-products/Stats_Brief_Issue29_Big_data_for_population_and_social_statistics_Apr2021.pdf ; and
United Nations Economic and Social Commission for Asia and the Pacific, "Big Data for the SDGs: country examples in compiling SDG indicators using non-traditional data sources", Working Paper Series SD/WP/12, January 2021b. Available at https://unescap.org/sites/default/d8files/knowledge-products/SD_Working_Paper_no12_Jan2021_Big_data_for_SDG_indicators.pdf

Health management

5. Cambodia: Satellite imagery usage for detecting hazardous areas

Landmines and other explosive devices are buried or hidden underground, which are hazardous areas that present serious dangers and risks to people. It is estimated that about 5,000 people (2019) are injured or killed by landmines every year, with the number of active landmines unknown.[44] Digital technologies are playing a larger role in helping to understand land cover before a mine clearing process is undertaken, providing valuable information in informing where potential land mines may be. Satellite imagery of land-cover contains key information which can be reviewed before starting the mine clearance process.

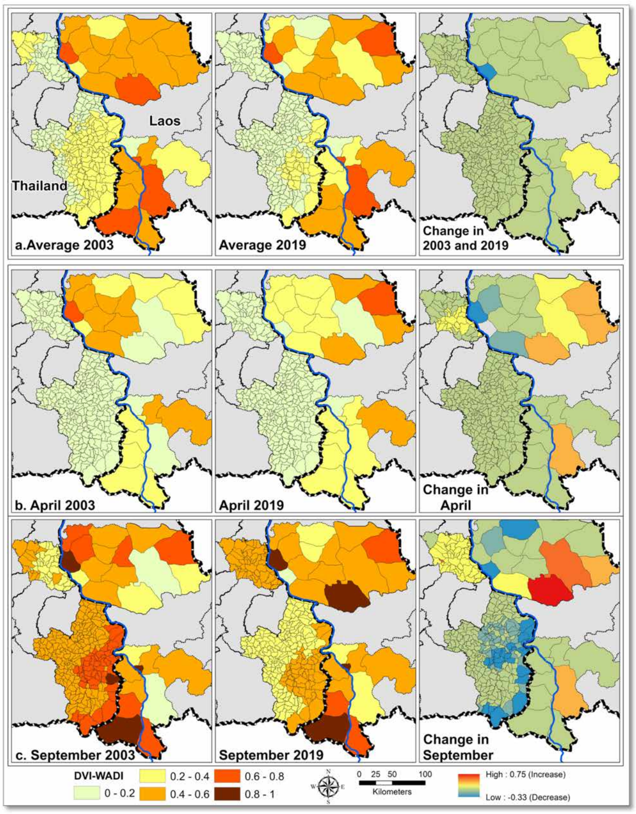
In a case study on land cover analysis using satellite imagery, researchers used Sentinel-2 remote sensing images, from 2019 to 2020, to analyse land-cover in both vegetated and non-vegetated areas, in Cambodia.[45] An expert in landmine surveying defined hazardous areas of focus, and a change matrix based on the successive images was created for each of the hazardous areas. Characteristics of the changes, namely the number of changes, were extracted from these matrices using pre-defined class-change scores. It was found that this analysis helped improve the productivity of land release through identifying clearance priorities and allowing for better resource allocation.

6. Lao People's Democratic Republic and Thailand: Increasing the understanding of dengue vulnerability[46]

As dengue is a constant burden to the health population in the Lao People's Democratic Republic and Thailand, better understanding of the vulnerability to dengue will allow for better prevention and intervention. Research, undertaken in 2021, used geospatial based approach to conduct a dengue vulnerability index using a multi-criteria decision analysis.

This study created three different dengue vulnerability indices (DVIs) that demonstrate connections between population, social and physical environments, and health (Figure 2.26). Each DVI was developed with consideration for identifying exposure, susceptibility, and adaptive capacity, or the ability to cope with or prevent dengue outbreaks, as key indicators. Input data included land use and land cover from satellite imagery, monthly mean temperature and average precipitation data, along with historical data on dengue cases from provincial health departments. Then, each DVI was validated against the dengue incidence for each district and subdistrict through mapping. It was found that the most suitable DVI was the Water-Associated Disease Index. This DVI showed high vulnerability to dengue in central urban areas as well as in areas with plantations or forests. It also showed high vulnerability in areas affected by climate and land cover change that were not necessarily very populated. This DVI is suitable to be used for other water-associated diseases as well.

Figure 2.26: **Dengue Vulnerability Index–Water Associated Disease Index**



Source: Sumaira Zafar, and others, "Development and Comparison of Dengue Vulnerability Indices Using GIS-Based Multi-Criteria Decision Analysis in Lao PDR and Thailand", *International Journal of Environmental Research and Public Health*, vol. 18, No. 17 (2021). Available at https://doi.org/10.3390/ijerph18179421

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Contamination and pollution

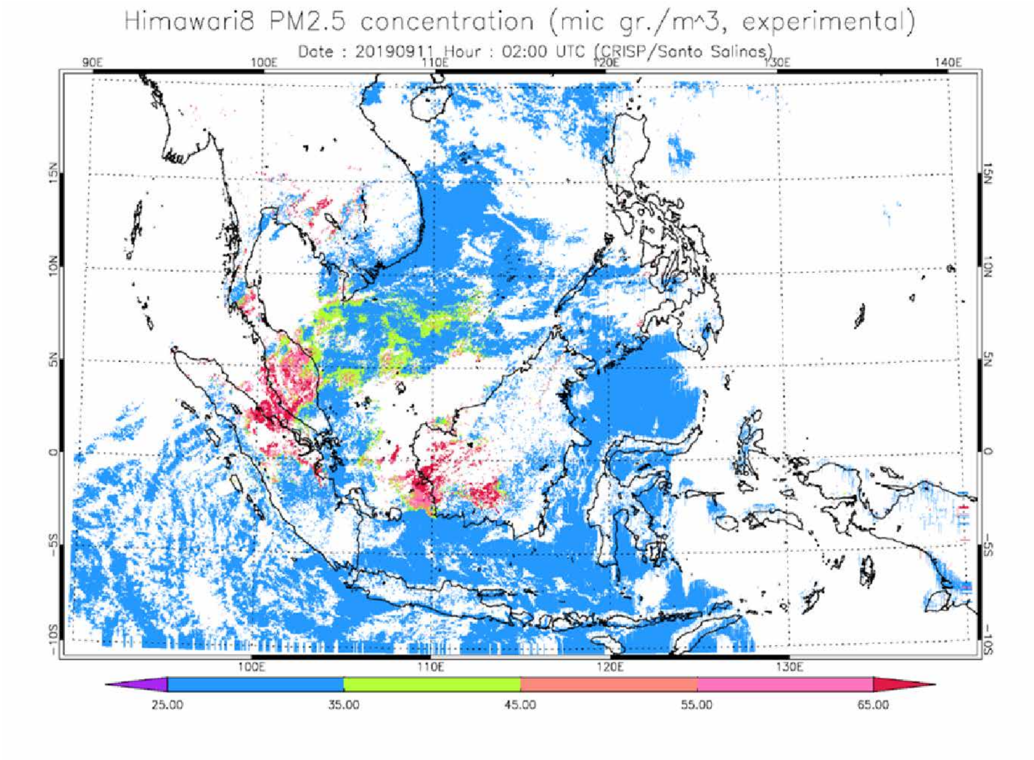
7. Singapore: Monitoring health impacts of air quality using satellite data[47]

Strategic Studies of Singapore Atmospheric Environment

CRISP participated in a project led by the NUS Environment Research Institute (NERI), focusing on the study of the characteristics and potential health impacts of PM2.5 in Singapore. An initial assessment of feasibility, potential and technological challenges was carried out. An 18-month long statistical study of PM2.5 and photometric aerosol particle concentrations was accomplished.

The aerosol optical depth (AOD) derived from satellite data (such as MODIS) could be used as a proxy for PM2.5. However, AOD is a parameter integrated over the whole thickness of the atmosphere while PM2.5 is measured at the ground level. It was found that correlations between AOD and PM2.5 could be established after correction for the planetary boundary layer (PBL) height (retrievable from MPL Lidar) and relative humidity (RH). Relations between AOD and PM2.5 at different seasons for years 2015 and 2016 were studied. Based on the results of these studies, a model was derived for converting satellite observed AOD to PM2.5. The model was implemented to produce hourly PM2.5 maps over the region using Himawari-8 data (Figure 2.27).

Figure 2.27: Regional map of PM2.5 based on Himawari-8 aerosol data product. Sample image corresponds to 02:00 UTC on the 11 September 2019



Source: Himawari8 satellite data, Japan Aerospace Exploration Agency (JAXA), 2019.

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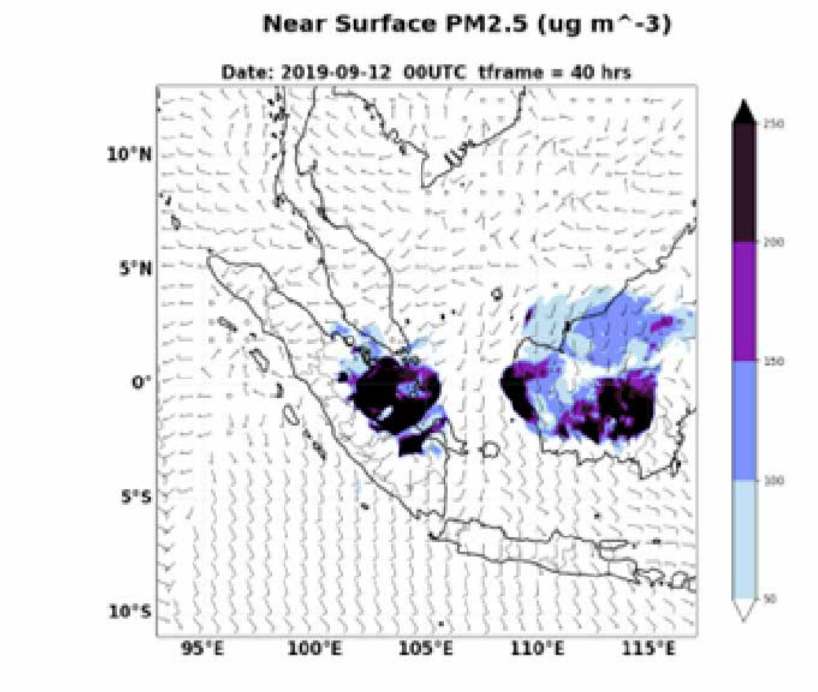
Regional Air Quality Monitoring and Forecasting

In 2015, CRISP started developing capabilities in running a numerical weather prediction model (WRF-Chem) to drive a regional haze transport forecasting model, especially for periods in which large episodes of biomass burning occur. A detailed study of the September 2019 episode of smoke haze that occurred over South-East Asia was carried out using WRF-Chem over a 9 x 9 kilometre square grid to simulate the formation and transport of biomass-burning smoke across the region. Results showed that WRF-Chem was able to capture the hazardous smoke haze reasonably well using both the Global Forecast System, a weather forecast model produced by the National Centers for Environmental Prediction, and the “Final” Analysis,(which is also produced by NCEP, but with different data assimilation strategy) data sets as a starting boundary condition, and the Fire Locating And Modeling of Burning Emissions project of the Naval Research Lab, as a specific fire source allocation. An operational framework for a WRF model for haze transport and forecasting is under development (Figure 2.28).

Figure 2.28: Weather Research and Forecasting (WRF) model coupled with Chemistry (v. 3.6) simulation of regional aerosol dispersion and transport during the 2019 smoke event. Model initialization is at 12 September 2019 00UTC. Snapshot corresponds to 40 hours after initialization



Source: Submitted by Singapore, and the National University of Singapore in response to the questionnaire of the ESCAP secretariat, 2019.

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Theme 5 - Energy

7 AFFORDABLE AND CLEAN ENERGY

Nearly half a billion people in Asia and the Pacific still lack access to electricity. Thus, more than 80 per cent of the countries in the region need to implement targets to improve energy efficiency.[48] Given the uneven distribution of energy resources in the Asia-Pacific region, affordable, reliable, sustainable and modern sources of energy are a prerequisite for achieving many of the Sustainable Development Goals.

The region has seen an increase in space technology, such as an increase in meteorological satellites, to help understand and map renewable energy distribution, with several South-East Asian countries leveraging these technologies. However, there are more opportunities for countries within the region to effectively use space-derived data for identification and mapping of renewable energy potential, effectively upscaling and improving their renewable energy usage.

Renewable energy infrastructure site appraisal

1.ESCAP: Expert World Group on Universal Access to Modern Energy Services[49]

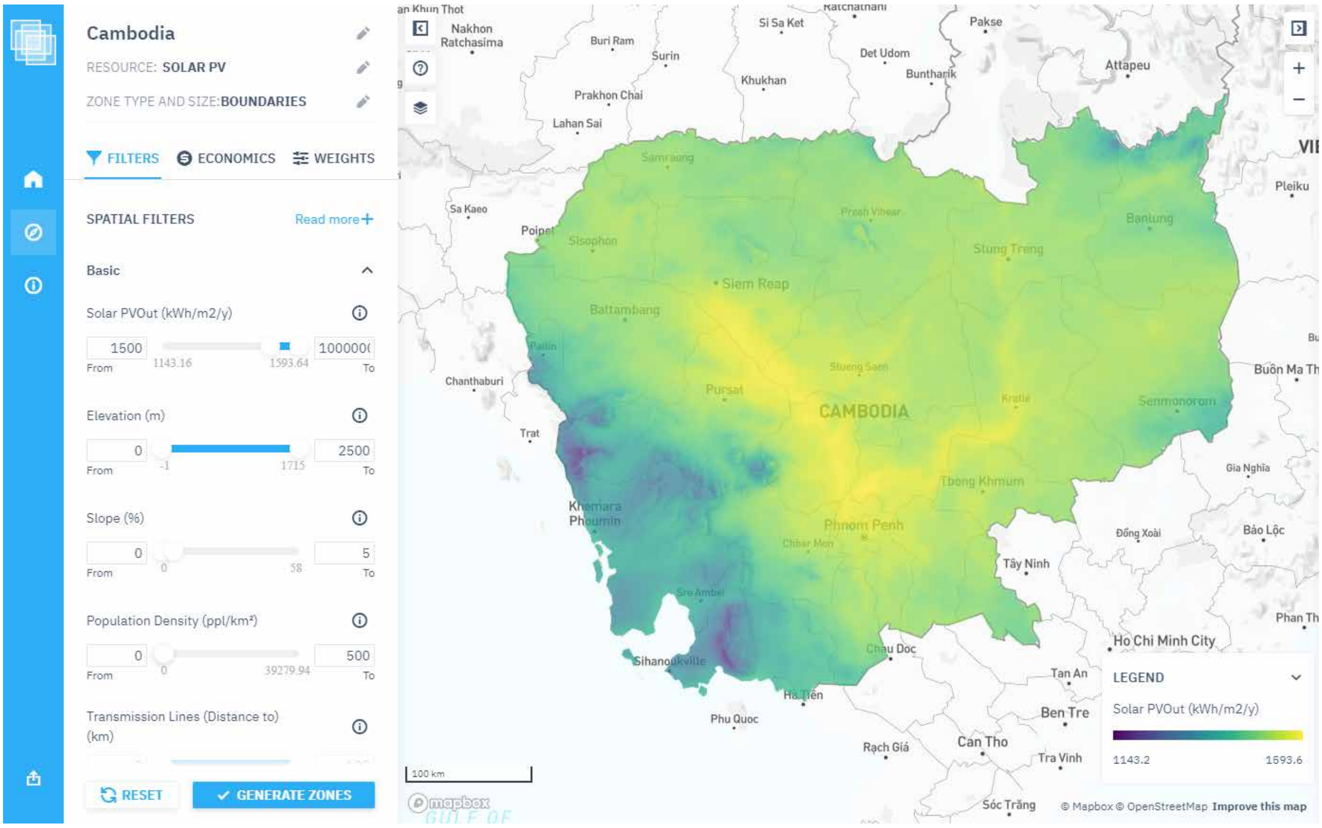
ESCAP convened the meeting, Expert Working Group on Universal Access to Modern Energy Services, to share best practices and experiences in developing, managing, and working with spatial data on energy, and to explore opportunities for its use in energy policy and planning with support from the secretariat. It is a step towards enabling member States to be in a better position to utilize geospatial data and analysis for energy policy and planning. On the part of the secretariat, insights gathered from the meeting support the development of geovisual analysis of new forms of energy potential in the Asia Pacific Energy Portal,[50] that illustrates energy transition paths for individual member States and regional partners. The meeting also highlighted opportunities for enhanced partnership and cooperation for spatial data on energy.

2. The Renewable Energy Zoning Tool (REZoning)

The Renewable Energy Zoning (REZoning) tool, an initiative of the World Bank, is an interactive, web-based platform designed to identify, visualize, and rank areas that are most suitable for the development of solar, wind, or offshore wind projects. It provides a spatial planning tool for renewable energy, with custom spatial filters and economic parameters which can be applied to specific country contexts (Figure 2.29).

The web-based platform has custom spatial filters and custom economic parameters for identification of the sites. Several public global datasets are also included in the platform, such as elevation, slope, population density, transmission lines, water bodies, land cover, roads, airports, protected areas and UNESCO World Heritage Sites. By including this baseline data, users gain a comprehensive overview, with all factors being taken into consideration. The output, is a ready-to-use tool which can provide on-demand analysis of renewable energy outputs, available for use by government officials, regulators, utilities and academia.[51]

Figure 2.29: REZoning: A web-based platform



Source: Energy Sector Management Assistance Program (ESMAP) and others, "REZoning: The Renewable Energy Zoning Tool", n.d. Available at https://rezoning.energydata.info/. (accessed on 13 September 2022).

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. Thailand: Renewable energy projects

Thailand's renewable energy improvement[52]

In recent years, sustainable energy has become a significant key to providing green energy at a low cost. New renewable energy sources are important in order to achieve widespread access to sustainable energy and contribute to the SDGs. Therefore, the effective integration between space technology and information technology has become the target tool for informing decision-making; through locating renewable energy sources and providing potential renewable energy maps.

Thailand announced at the twenty-sixth Climate Change Conference of the Parties (COP 26) that it would increase its long-term ambition on climate action, pledging to reach carbon neutrality by 2050 and to achieve an economy with net zero greenhouse gas (GHG) emissions by or before 2065. Thailand continues to intensify the target of implementing renewable energy at the national level in the long and sustainable term. In the next decade, 10 GW of renewable electricity are forecasted to grow, in which 4.45 GW of solar energy will play a dominant role in the decentralized electricity generation of Thailand.

During Phase I, the Department of Alternative Energy Development and Efficiency implemented projects to explore potential solar energy. This project used satellite data and information from the United States' National Oceanic and Atmospheric Administration's (NOAA) Geostationary Operational Environmental Satellite (GEOS) and the Himawari-5 Geostationary

Meteorological Satellite, to establish the model and solar irradiance profile of Thailand using meteorological data.

GIS for site selection of hybrid, firm renewable energy-based power plants in Thailand[53]

With renewable energy-based power plants that utilize wind, solar, and biomass resources, appropriate site selection is a key component in developing an optimized power plant. This study looked at site selection in southern Thailand for Small Power Producers (SPP) hybrid, firm power plants. This was done through the use of the Analytical Hierarchy Process (AHP) using GIS tools.

In terms of considered energy resources, input data was a para rubberwood distribution map, the Global Horizontal Irradiance (GHI) map, and a wind potential map, all of which were overlaid. Additionally, a further consideration for SPP is energy storage and the potential for inclusion of an energy storage system on the site was also evaluated. AHP was used to evaluate the data of the input maps and a new map with suitability scores was created in GIS where an overlay intersection technique was used to identify potential SPP sites.

With additional environmental and economic considerations, 14 power plant scenarios were ranked, and the most optimal scenario was derived. The methodology used by this case study shows that AHP and GIS can be effectively used to optimize site selection to target renewable energy resources.

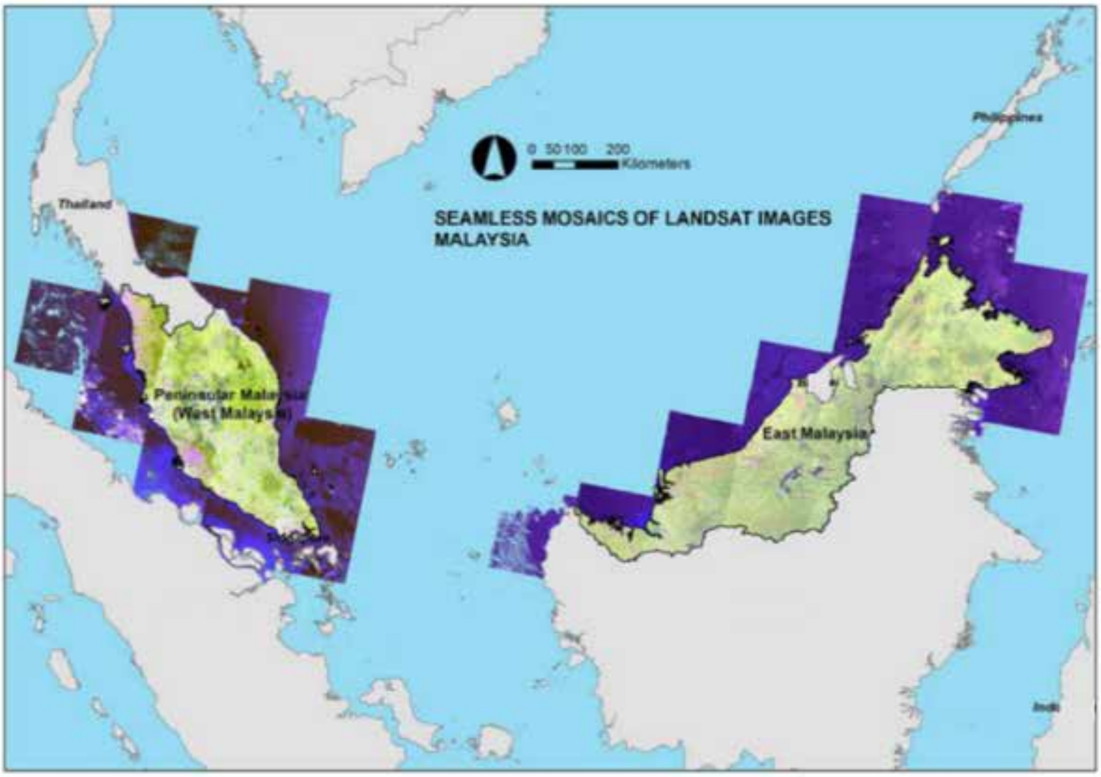
4. Malaysia: Identifying potential wave energy locations using GIS

Wave energy is a promising renewable energy technology, which uses different methods of harnessing the motion of waves by placing electricity generators on the ocean surface. Due to Malaysia's vast coastline, this is a potential renewable energy source that may be able to meet Malaysia's growing energy demand. However, this technology, although one of the most powerful, is relatively underdeveloped.

Research was undertaken to identify the potential energy at wave locations, by using wave data obtained from the Malaysia Meteorological Department. Using geospatial tools, analysis has been undertaken to determine suitable sites for new marine energy. GIS was used to produce interactive digital and hardcopy maps. Using these geospatial outputs and maps, researchers compared wave energy maps from different years to identify potential locations for wave energy.

Researchers found that, in Malaysia, the greatest potential for wave energy exists within the northern portion of the Borneo Island, with the Sabah region having particularly high potential. Based on the analysis, wave energy devices could generate up to 160kW/m within the Sabah region, and 150kW/m for Peninsular Malaysia. Decision makers and related stakeholders can use the results and output from this research to plan the future of new energy development in Malaysia, especially in Marine Energy. GIS analysis and geodata, can help to map renewable energy potential; pushing wave energy to play an increasing role in complementing other renewable and conventional energy technologies to meet global needs (Figure 2.30).[54]

Figure 2.30: Wave Energy



Source: Khairul Nizam Abdul Maulud, and others, "Identification a Potential Wave Energy Locations In Malaysia Using GIS", Proceedings of the 10th WSEAS international conference on Mathematical methods, computational techniques and intelligent systems. October, 2008. Available at https://www.researchgate.net/publication/262277487_Identification_a_potential_wave_energy_location_in_Malaysia_using_GIS

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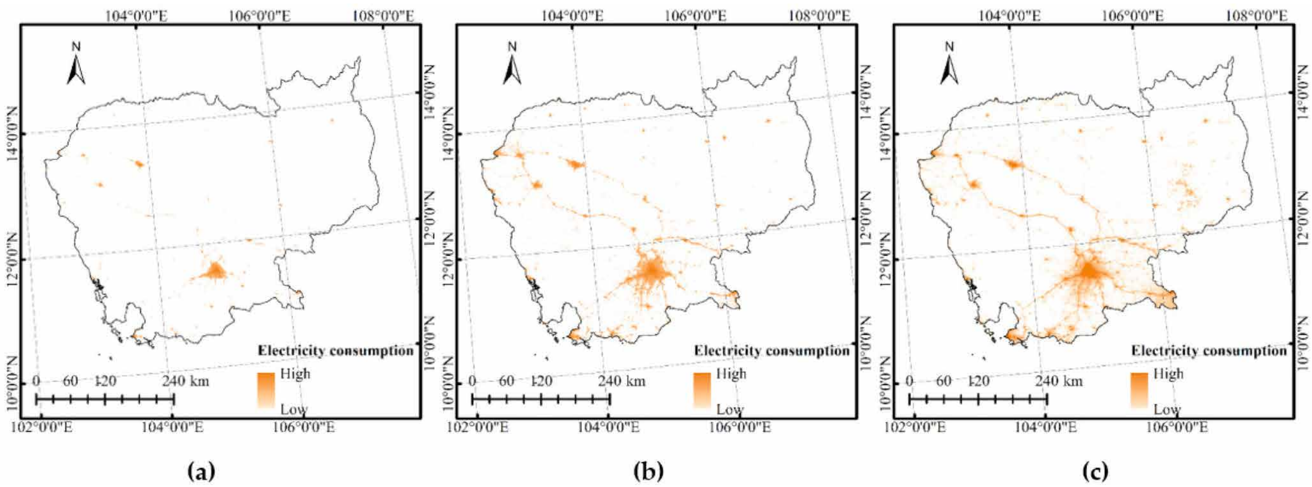
Mapping energy consumption

5. Cambodia: Modelling electricity consumption using remote sensing night imagery[55]

Knowing the spatial distribution of electricity consumption is important for electricity infrastructure planning and for achieving SDG 7. It is possible to estimate electricity consumption through correlation to night-time light use as is observed in remote sensing images, otherwise called night-light images. Different methods, tested through research, to synthesize and denoise night-light images of cloud cover have been tested, and then electricity consumption has been estimated. It was found that the month-specific substitution method was the most effective to create accurate annual light image data. Then, the exponential model was found to be the best fit to relate total night-light values to electricity consumption.

The methods used were successful in demonstrating that Cambodia's four most economically developed cities consume the greatest amount of electricity, with consumption spreading out along the main transport routes from these cities towards unelectrified areas. This information provides valuable contributions to future planning of electricity infrastructure in Cambodia (Figure 2.31).

Figure 2.31: Spatial distribution of electricity consumption in Cambodia, over three years (2012, 2015 and 2018)



Source: Xumiao Gao, and others, "Modelling Electricity Consumption in Cambodia Based on Remote Sensing Night-Light Images", *Applied Sciences*, vol. 12, No. 8 (2022). Available at https://doi.org/10.3390/app12083971

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6. The Philippines: Cloud-based Monitors and Electronic Sensors (e-sensors) for energy conservation

The Department of Science and Technology (DOST) in the Philippines is endorsing ICT technology for energy saving. The large private buildings and government facilities are urged to use cloud-based monitors and electronic sensors (e-sensors) to monitor their energy consumption and conserve it with optimum utilization.

Smart technology is being utilized to enable organizations to monitor their energy consumption. Owing to the rise in global fuel prices, Cloud-based Monitors and Electronic Sensors (e-sensors) are used in buildings to ensure that the energy is conserved. In this regard, the use of electric vehicles and charging stations across the provinces, called the CHARM (Charging in Minutes), are established that enables an e-vehicle to be recharged in 30 minutes from the previous 8 hours. In addition, the Internet of Things (IoT) and smart technology have been frequently utilized in helping organizations reduce their power usage. The technology provides real-time data that enables efficient and faster energy monitoring and serve as frontline tools in reducing carbon footprints.[56]

Theme 6 - Climate Change

Climate change has already impacted the Asia-Pacific region; with higher temperatures, a rise in sea level, and extreme weather events.

Responding to climate change is a major global challenge. The implementation of the United Nations Framework Convention on Climate Change and the Paris Agreement is essential to the achievement of several Sustainable Development Goals.
The innovative use of geospatial information for climate studies and scenario development, including impact and vulnerability mapping, will be essential.

Collaboration to build capacity towards climate resilience

1. ESCAP: Strengthening geospatial capacity in Lower Mekong countries[57]

To strengthen the capacity of member States in lower Mekong countries, ESCAP has been implementing a project titled "Building resilient agricultural practices by integrating geospatial information for agricultural monitoring in the Lower Mekong Basin: An emphasis on rice condition", from 2019 to 2022, with support from the Institute of Remote Sensing and Digital Earth, Chinese Academy of Sciences (Figure 2.32).

ESCAP, in collaboration with several partners,[58] is enhancing the capacity of target stakeholders to use geospatial data applications to monitor agricultural crops in relation to identifying planting areas, potential climate change risks and options for human intervention. This would ultimately contribute to strengthening food security and livelihoods of vulnerable rice growing countries at the national and provincial levels. This project is cross cutting, contributing to several SDGs and their targets, and addressing three of the six thematic areas; disaster risk reduction and resilience; natural resource management; and climate change.

The objective of the project is to strengthen the capacity of the lower Mekong countries (Cambodia, Lao People's Democratic Republic, Myanmar, Thailand and Viet Nam) to identify suitable climate resilient agricultural practices in rice crop production, through enhanced access to digital early warning monitoring information for climatic shocks, transboundary water issues and georeferenced production forecasts. This will be achieved through two main activities:

a) The development of a crop monitoring system and supporting data, information and applications which combines ground-based information with satellite data to calibrate the system to national conditions.

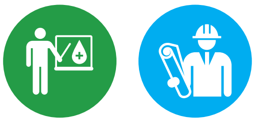
The regional service nodes in China and Thailand have designed a customized CropWatch Cloud and operational tools with an interface in local languages that provide relevant agricultural monitoring services up to the local level in the lower Mekong basin. This supports time-critical cropping decisions that need to be made and unlock the power of geospatial information to government officials through overcoming language barriers.

b) Building awareness and capacity of governments from participating countries to utilize the system, to further access and utilize space applications for agriculture and other purposes and integrate tools into their institutional procedures, policies and programmes where appropriate.

Figure 2.32: **Field work during the Lower Mekong Project**

Source: ESCAP, Space Applications Section (2022).

2. ESCAP: Building institutional capacity for the use of integrated spatio-temporal data in local SDGs monitoring and decision-making



China completed a comprehensive assessment of the overall progress towards achieving the SDGs in Deqing, Zhejiang Province, through a data-driven measuring and evidence-based analysis. From the Sustainable Development Goals indicator framework, 102 indicators were measured using integrated geospatial and statistical information. Qualitative and quantitative analysis was conducted at indicator, single goal and multi-goal levels. Based on the results, the Deqing's County Plan on Implementation of the 2030 Agenda for Sustainable Development (2021-2025) was completed. Such analysis demonstrates how spatio-temporal data, from Earth observation and other sources, was developed and delivered to inform decisions.

In working towards achieving the SDGs, integrating georeferenced data from various sectors with satellite-generated data is essential for accurate and comprehensive SDG monitoring, assessment and planning. ESCAP, in collaboration with SDG centres of Makassar and Bandung, Indonesia, as well as the city of Songkhla and Prince Songkhla University, Thailand, is supporting the development of an integrated geospatial data guideline. The guideline will be critical in converting geospatial big Earth data into SDG-related information to support decision makers in pilot cities.

The project aids beneficiaries to construct a tailored geospatial information integration system for selected SDG indicators. The SDG centre in Makassar requested the monitoring of SDG indicators related to fisheries, tourism and coastal ecosystems. The SDG centre in Bandung desired to solve problems related to solid waste, health and slums. The Songkhla city government requested a comprehensive analysis and monitoring of coastal ecosystems, urbanization and floods.

The tailored and user-focused approach allows the project to investigate the inter-linkages between various geospatial information and the SDGs, and provides analysis and training that combines the theory with the practice for local-level policymaking.

Innovative tools and methods for climate related mapping

Box 3: PRiSM, a Climate Risk Monitoring platform to facilitate risk-informed decision-making

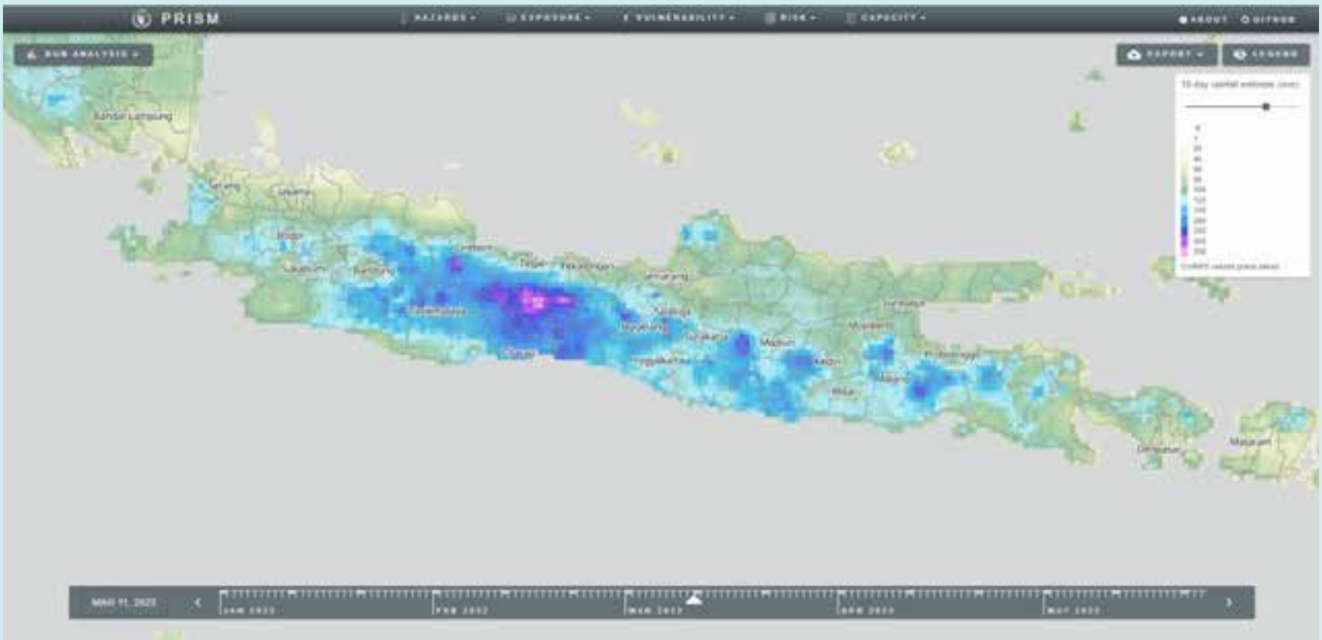
PRISM is a web-based platform which supports government agencies to rapidly assess climate hazard risks and their impacts to inform disaster risk management and social protection programs. PRiSM simplifies the integration of geospatial data on hazards, such as droughts, floods, tropical storms, and earthquakes, along with information on socioeconomic vulnerability to present decision makers with actionable information on vulnerable populations exposed to hazards.

PRiSM is operational in Cambodia and Indonesia, and is at various stages of deployment in Kyrgyzstan, Tajikistan and Sri Lanka.

- In Cambodia, PRiSM is operational within the National Committee for Disaster Management to monitor climate hazards from satellite products and ground observations (water level data from EWS1294 and field data), assess the impacts and support decision-making for disaster risk management. Further, PRiSM will be integrated with IDPoor, the government's poverty identification and registration database, to provide information on geographic extent of climate hazards and the exposure of poor and vulnerable households, enabling the social protection system to identify and provide assistance.

- In Indonesia, PRISM caters to the information needs (satellite-observed climate and vegetation products) of various government stakeholders for their operational and planning contexts. The World Food Programme (WFP), along with government partners, use PRiSM data layers for impact analysis and food security assessment. The Climate Early Warning System of Indonesian Meteorology, Climatology, and Geophysical Agency use PRISM's satellite-based rainfall data to complement the Agency's data to monitor climate variability, and the satellite-based rainfall data offsets the data gaps from ground observations. PRiSM showed 10-days accumulated rainfall over Central Java during 11-20 March 2022 (Figure 1), when central Java experienced flooding and landslides.[a] PRiSM is linked with the Ministry of Social Affairs' Disaster Mitigation Information System (e-SIMBA) platform to provide climate hazard information for guiding social protection to those most in need of assistance. The Ministry of National Development Planning will integrate PRiSM as a component of its food system dashboard to monitor vegetation and crop condition to support agricultural monitoring to inform planning and budgeting. Combining data from PRiSM and Government Platforms/Systems, especially on climate hazards and cropping area, enables policymakers to estimate food insecurity scenarios, and thereby rapidly scale-up the program to support populations who have been pushed into transitory food insecurity triggered by climatic hazards.

Figure 1: **Screenshot of PRISM Indonesia showing rainfall observed over Central Java, 11-20 March 2022**



Data Source: Climate Hazards Center, "CHIRPS: Rainfall estimates from rain gauge and satellite observations", 2022. Available at https://www.chc.ucsb.edu/data/chirps; and PRISM. Available at https://prism.wfp.or.id/app/?hazardLayerId=rainfall_dekad&date=2022-03-11

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Recognizing the changing risk patterns, technological developments, growing needs of risk analytics within government agencies, PRiSM deployment in countries are planned as a continuous process to ensure its relevance and ownership within government agencies. PRiSM deployment is advantageous for the following reasons; i) open source, easy to absorb, and scalable technology, which will enable easier integration and promotes ownership within government agencies; ii) while being tested/used by operational agencies, the evidence and demands are continuously assessed to ensure functionalities and analytics are improved through the dedicated technical team at WFP, and the enhanced utilities are available for other PRiSM deployed countries; iii) integrates innovative products available globally and regionally (e.g. SERVIR Mekong) to maximize the utility of PRiSM, as well as get linked with other systems (e.g. IDPoor, Social protection System in Cambodia) to share PRiSM's data; and iv) PRiSM ensures interoperability through adoption of standards set forth by the Open Geospatial Consortium.

a. Richard Davies, "Indonesia – Floods affect 50,000 in Java, Borneo and Sumatra", *Floodlist*, 18 March 2022. Available at https://floodlist.com/asia/indonesia-floods-march-2022

Source: Submitted by World Food Programme (WFP).

3. SERVIR-Mekong utilizing satellite data for climate response[59]

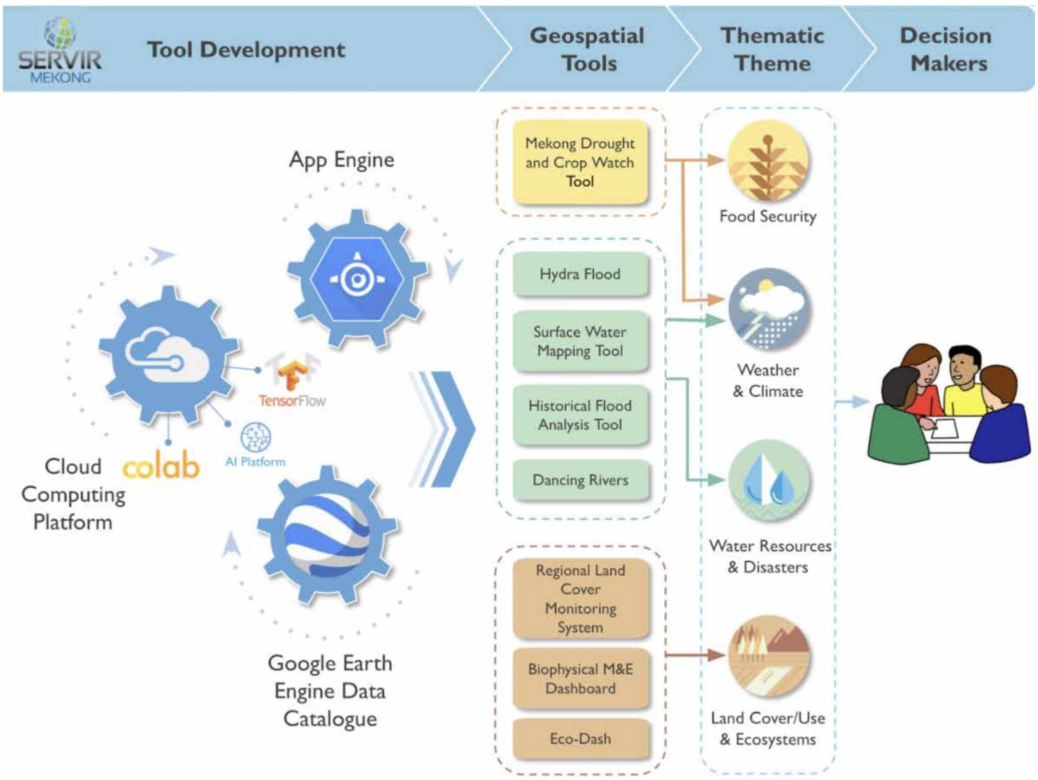
SERVIR-Mekong, an initiative between the U.S. Agency for International Development (USAID) and the National Aeronautics and Space Administration (NASA) and implemented by the Asian Disaster Preparedness Centre (ADPC) is using space applications to strengthen disaster response.

During the 2020 extensive flooding in Cambodia, that affected over 790,000 people, SERVIR-Mekong used Google Earth Engine (GEE) and satellite imagery to provide daily flood extent data for the World Food Programme (WFP) to integrate into their comprehensive disaster risk management platform. Data was integrated into their Platform for Real-Time Impact and Situation Monitoring (PRISM),[60] which enabled the World Food Programme to produce timely and accurate flood map products and situation reports to inform government and humanitarian partners.

SERVIR-Mekong uses publicly available satellite data to improve development outcomes and help address environmental and development challenges related to climate change. Google Earth Engine has been leveraged by SERVIR-Mekong to develop and deploy many decision-support tools and services, including drought monitoring and forecasting, environmental management, and water resource management. These tools are customizable and once developed for the Lower Mekong region, can be scaled down to address a country's specific needs (Figure 2.33).

The use of geospatial applications in climate adaptation and environmental management provides an innovative way to collect and analyze data, applying the outcomes to help inform decision-making.

Figure 2.33: Development of SERVIR-Mekong tools



Source: USAID, "USAID's SERVIR-Mekong and Google partnership enhances climate change adaptation in the Lower Mekong", 28 June 2021. Available at https://servir.adpc.net/news/usaids-servir-mekong-and-google-partnership-enhances-climate-change-adaptation-lower-mekong

4. Cambodia: Digital GIS Climate Change Toolkit[61]

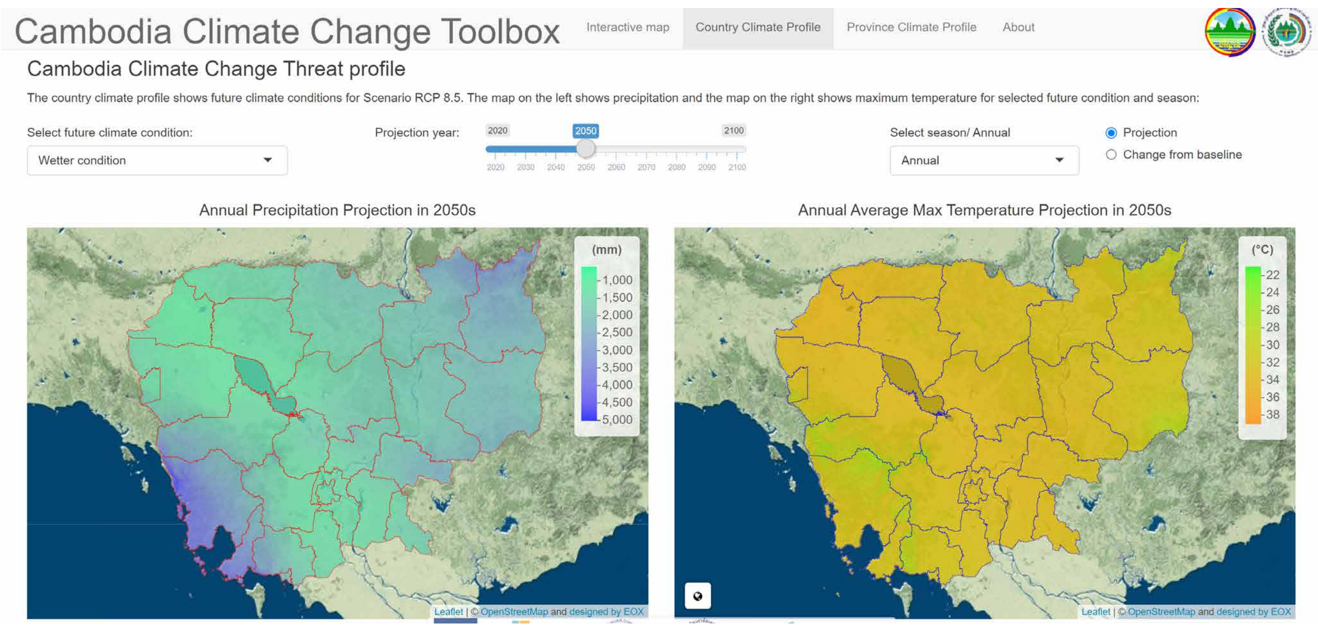
The Cambodian Climate Change Toolkit is an open-source information portal that provides projections and data on climate-related parameters in Cambodia (Figure 2.34). Data is provided at the country, provincial, district and local-levels which will support the decision-making process within the government of Cambodia. The digital portal is being created by the International Conference on Electrical Machines (ICEM) and executed by Cambodia's Ministry of Environment (MoE).

The toolkit enables the staff in the Cambodian government to see what climatic changes are occurring and are predicted to occur in areas where development is being planned. In addition, it provides a platform for projected climate change parameters to be incorporated in project design and management across all government sectors. The toolkit contains a GIS-based decision-support tool, which will be available on the web. It provides a climate change projection interface for numerous parameters at different administrative levels throughout Cambodia and is intended for use by infrastructure and development planners, and government workers.[62]

One of the main objectives of the project is technical capacity-building of government staff, to allow them to assess vulnerability of development plans and adapt accordingly. This will lead to mainstreaming climate resilience into development planning.

Within the toolkit's online platform, the main components include: a) an interactive map, which allows users to query climate data using area locations; b) country and province climate profiles, a dual-map showing projected precipitation, and maximum temperature for the 2050s for the country; and c) an 'About' section which explain data sources, terminology and methodology.[63]

Figure 2.34: Screenshot of the Cambodia Climate Change Toolbox



Source: Asian Development Bank (ADB), and others, "Cambodia Climate Change Toolbox". Available at http://dss.icem.com.au/CambodiaDSS/ (accessed on 13 September 2022).

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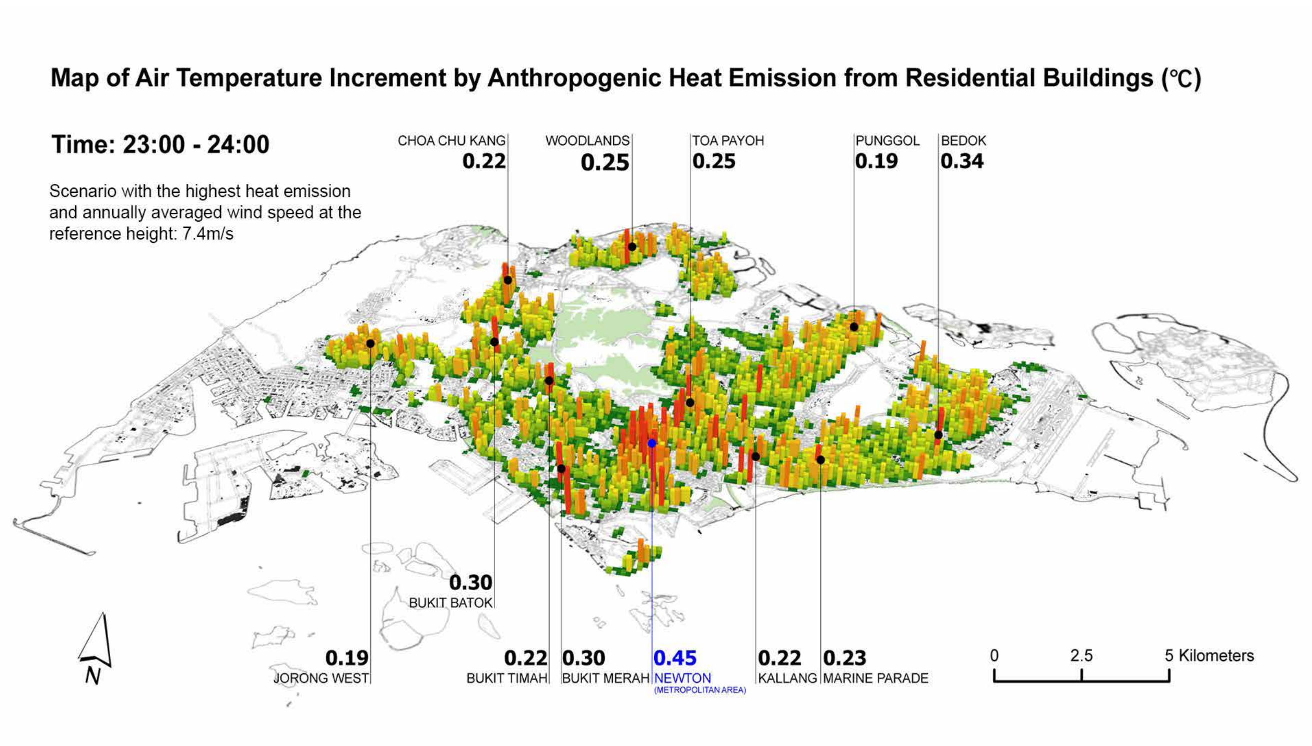
5. Singapore: New urban planning GIS tool to improve urban climate resilience[64]

Singapore is one of the most densely populated countries in the world and combined with the geographic distribution of this low-lying city-state, the country is severely vulnerable to the consequences of climate change.

To regulate the average annual temperature and enhance urban climate resilience, a team from the Department of Architecture at the National University of Singapore, School of Design and Environment examined the heat balance in the street canyon where the street is flanked by buildings on both sides. Researchers developed a GIS tool to estimate the impact of urban planning on anthropogenic heat dispersion. The model provides an efficient and economical alternative for urban planners to estimate the impact of urban planning and design on anthropogenic heat dispersion. Due to the large uncertainty caused by urbanization on climate change, this GIS-based analytical model is a feasible tool which can model several microclimate scenarios to help Singapore in regulating temperatures during the summer.

Beyond applications in Singapore, other neighbouring cities can adopt this practical model by seamlessly connecting this model to global and regional scale models and data. City-level findings can also be used to tackle anthropogenic heat problems globally (Figure 2.35).

Figure 2.35: Map of air temperature by anthropogenic heat emission from residential buildings



Source: National University of Singapore, "NUS Researchers develop new urban planning GIS tool to improve urban climate resilience", UNDRR. 29 July 2022. Available at https://www.preventionweb.net/news/nus-researchers-develop-new-urban-planning-gis-tool-improve-urban-climate-resilience https://www.sciencedirect.com/science/article/abs/pii/S0378778820333995

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6. Thailand and ASEAN: Integrated Climate Observing System

An Essential Climate Variable (ECV) is a group of linked variables that critically contribute to the characterization of Earth's climate and the radiative forcing of climate change. There are 54 variables in ECV of which 32 variables can be derived from satellite in combination with ground stations. Some ECVs influence plant growth and productivity, while the variability in other ECVs can result in disasters. Adaptation preparedness to reduce losses and mitigate climate change impacts needs to rely on integrated knowledge in a multidisciplinary approach which are founded upon reliable, accurate and up-to-date spatial data. ECVs, which are based on systematic and synthesis data processing, can support adaptation preparedness and in turn improve decision-making and planning at both policy and operational levels.

The aim of the "Integrated Climate Observing System in Thailand and ASEAN" is to provide an online ECVs database of Thailand and ASEAN, which is derived from satellite and ground stations. The provided ECVs will have a higher temporal and spatial resolution for both Thailand and the ASEAN region, as compared to global scale resolutions which are available from other agencies. The online database will allow all sectors, including the government, private and public sectors to have unlimited access to data which can further be used in forecasting climate change as well as anticipating the impacts that will occur on the society, the economy and the environment. This example highlights how remotely-sensed data is helping the general public, along with decision makers to better track and manage the impacts of climate change, along with improving tools to mitigate GHG emissions.

7. Indonesia and Viet Nam: Monitoring mangroves using remote sensing

Mangroves are important to the ecosystem and provide natural infrastructure and protection, preventing erosion and absorbing the impacts of storm surges during extreme weather events. Mangroves also have the ability to store large amounts of carbon, making them a useful means to tackle climate change.

Indonesia: Remote sensing for rehabilitation of mangroves affected by plastic waste[65]

Indonesia contains the largest mangrove forests in the world, with mangrove forests found throughout many parts of the country, and making them the most carbon-dense forests in the tropics.[66] They contain more than three times as much mean carbon per hectare as land-based tropical forests.[67] However, Indonesia has lost 40 per cent of its mangroves over the past three decades, with some of the most significant contributors to their damage being land conversion and plastic waste, thereby making this mangrove destruction among the highest in the world.

Government and other stakeholders want to target mangroves for rehabilitation. However, traditional means of ground-based checks are labour intensive and time consuming, rendering them ineffective. Therefore, researchers have used a more effective and efficient identification of mangrove priority areas using satellite remote sensing data.

Researchers developed a geospatial method which assigns a vulnerability index, by classifying mangroves based on the severity of damage. Vulnerability was based on factors, such as plant health, water turbidity, and plastic waste distribution and machine learning was used by the model to distinguish the classes. The study identified that 65.74 per cent of Indonesia's coastal mangroves are extremely exposed to plastic waste, especially in Bali and Surabaya, which are two of the most severely damaged areas. This research helps to understand where these vulnerable mangroves are, and with the addition of further social, cultural and economic development priorities, decision-makers can prioritize these areas for suitable mangrove management and rehabilitation.

Viet Nam: Satellite data for monitoring mangrove growth

Mangrove forests are important to the ecosystem and play a large role in climate change adaptation and mitigation, which is especially important in Viet Nam since the country is becoming increasingly vulnerable to storm intensity and sea level rise. To help in climate change adaptation and mitigation, as well as to improve the livelihoods of the local community, mangrove forest restoration and rehabilitation has been institutionalized as a key adaption intervention for Viet Nam. However, these forests are under severe threat due to rapid population growth, insufficient governance, poor planning, as well as uncoordinated economic development.

Researchers undertook a geospatial methodology using satellite imagery to map comprehensive coverage of mangroves and analyse their changes over time. This study was undertaken in Hai Phong city and used both optical and SAR satellite data, from the Landsat programme. The results found that mangrove loss in Hai Phong city, between 1989 and 2010, was 985 hectares, which is an annual loss of 50 hectares.

Combined with social factors, research established that the mangrove degradation in Hai Phong was due to expansion of shrimp aquaculture. This research demonstrates the use of space-based data in establishing accurate mapping of mangroves, distinguishes the boundary of coverage area and health status of mangroves, thereby helping Viet Nam to gain a deeper understanding of the area which will help in mangrove rehabilitation and decision-making.[68]

8. Singapore: Use of satellite data to estimate sea level changes[69]

The Nanyang Technological University (NTU) and the Singapore Land Authority (SLA) have collaborated to use Global Navigation Satellite System (GNSS) data and new Singaporean coastal GNSS reference stations to measure land height and sea-level changes. In addition, this data will also help measure the effect of the atmosphere on the weather and climate in the country.

During the period of collaboration, the Earth Observatory of Singapore (EOS) processed historical GNSS data, provided by SLA, to assess how land height has changed at specific locations. This helps to improve the accuracy of elevation results obtained from remote sensing Interferometric Synthetic Aperture Radar (InSAR) technologies. EOS and SLA plan to install new coastal GNSS stations across Singapore, which will aid in the development of space-based technologies to monitor both land height and sea-level changes. These stations will also be integrated into the Singapore Satellite Positioning Reference Network (SiReNT) infrastructure and serve to maximize the use of resources. Data from existing SiReNT stations will also be included to support this objective.

By characterizing the atmospheric processes that affect Singapore at various timescales, scientists can find out where and when localized weather systems are likely to produce intense precipitation. EOS researchers will also aim to utilize the GNSS data in local meteorological research. Through detailed comparison and analysis of GNSS and meteorological data, scientists aim to better understand precipitation and severe weather events.

Trends and innovative technologies – Space+ for our Earth and future

As mentioned in Chapter 1, "Space+ for our Earth and future" (Space+) has been developed under ESCAP's RESAP mechanism, and it goes beyond the traditional space applications approaches to support the implementation of the Plan of Action and the SDGs.

Space+ promotes innovative applications of space technology and seeks to: (a) leverage innovative digital applications; (b) engage end users, including the private sector and youth; (c) manage data and information more effectively; and (d) enhance partnerships with national, regional and global stakeholders.

A few examples, that contribute to Space+ are highlighted throughout this section.

Geospatial innovation, data sharing platforms and integration technologies

1. ASEAN: Space+ promotion across young scientists

Space+ promotes and enhances knowledge amongst young scientists, as well as young users, in general. It promotes the sharing of best practices to promote women's participation in science and technology. The emphasis is on training a workforce with multidisciplinary expertise to develop and use integrated geospatial systems and analysis across the region in line with the modalities contained in the Plan of Action. Capacity development, that provides job and educational opportunities through scholarships, exchange programs and remotely through participation in massive open online courses, is crucial. As countries accelerate their utilization of geospatial technologies, long-term sustainability will rely on government policies that support the inclusion of technologies in national curriculums with special measures to increase the participation of young women.

Opportunities to connect internationally with peers is also important, such as the first Youth Forum on Space Application and the SPACE+ initiative that encouraged the innovative use of geospatial information for resilient and sustainable development. This Youth Forum was organized by ESCAP, in collaboration with the Geo Informatics and Space Technology Development Agency of Thailand (GISTDA), the Association of Southeast Asian Nations (ASEAN) Research and Training Center for Space Technology and Applications, Multi-GNSS Asia and the United Nations Satellite Centre (UNOSAT), Centre for Space Science and Technology Education in Asia and the Pacific, and the Asian Institute of Technology (AIT), which was held in Phuket, Thailand, in March 2022 (Figure 2.36 and 2.37).

Figure 2.36: Building capacity for the young professionals at the ASEAN Research and Training Center for Space Technology and Applications (ARTSA), Chonburi, Thailand

Source: ESCAP, Space Applications Section (2022).

Figure 2.37: Youth Forum on Space Applications and the SPACE+ initiative, 10-11 March 2022, in Phuket, Thailand

Source: ESCAP, Space Applications Section (2022).

Geospatial partnerships and training programmes

In addition to formal learning and training programmes, hackathons, and innovation challenge schemes present further opportunities to engage the youth. In this regard, Multi-GNSS Asia, and Geo-Informatics Space Technology Agency of Thailand (GISTDA) co-organize a yearly hackathon event titled "Rapid Prototype Development Challenge to explore youth-led innovations on "Solutions for Disaster Mitigation: Tsunami and Flooding".[70] In 2021, there were three winning teams. These included: a) Team Softwell, "Early Warning Systems for Glacial Outburst Floods"; b) Team RBRU-GI, "Real Time Water Current and Location Monitoring"; and c) Team Tala Tech, "Automatic Tsunami Early Warning System".

Similarly, ASEAN Geospatial,[71] a cooperative network of ASEAN geospatial agencies, companies, and professional networks partnered with the Philippines National Mapping and Resource Information Authority for the ASEAN Geospatial Challenge 2021: Geospatial Youth Edition. ASEAN Geospatial aims to cultivate good relationships and collaboration among the youth in ASEAN, elevate geospatial competencies, and raise interest in the geospatial field. Winning projects receive support by the sponsor agencies for further development and implementation.

In 2021, the challenge was organized by the Singapore Land Authority, and supported by Ministry of Development (Survey Department) of Brunei Darussalam, Ministry of Natural Resources and Environmental Conservation (Survey Department) of Myanmar, NAMRIA of the Philippines, and Ministry of Natural Resources and Environment (Department of Survey, Mapping, and Geographic Information) of Viet Nam.

The projects chosen to be supported were:

- GEO-AID: A Geospatial Database Crowdfunding Application Development of Team GEO-AID from University of the Philippines (UP) Los Baños (College of Forestry and Natural Resources).
- HIV and Support Facilities Mapping in the Philippines of Team MapBeks composed of UP Diliman (Department of Geography) and Polytechnic University of the Philippines San Juan Campus.

Both projects will be supported by partnering agencies for further development and use by concerned stakeholders as well as the public in the future.

2. The Philippines: PhilSA integrated network for space-enabled actions towards sustainability

The Philippines Space Agency, PhilSA, launched the Space Data Dashboard, in 2020,[72] which provides an online, interactive web platform to analyse and compare different sets of space-based data and information. This includes datasets on COVID-19 statistics, air quality, water quality, night lights/electrification, land cover data, disaster response maps (flood and landslide), flood maps and satellite imagery (Figure 2.38 and 2.39).

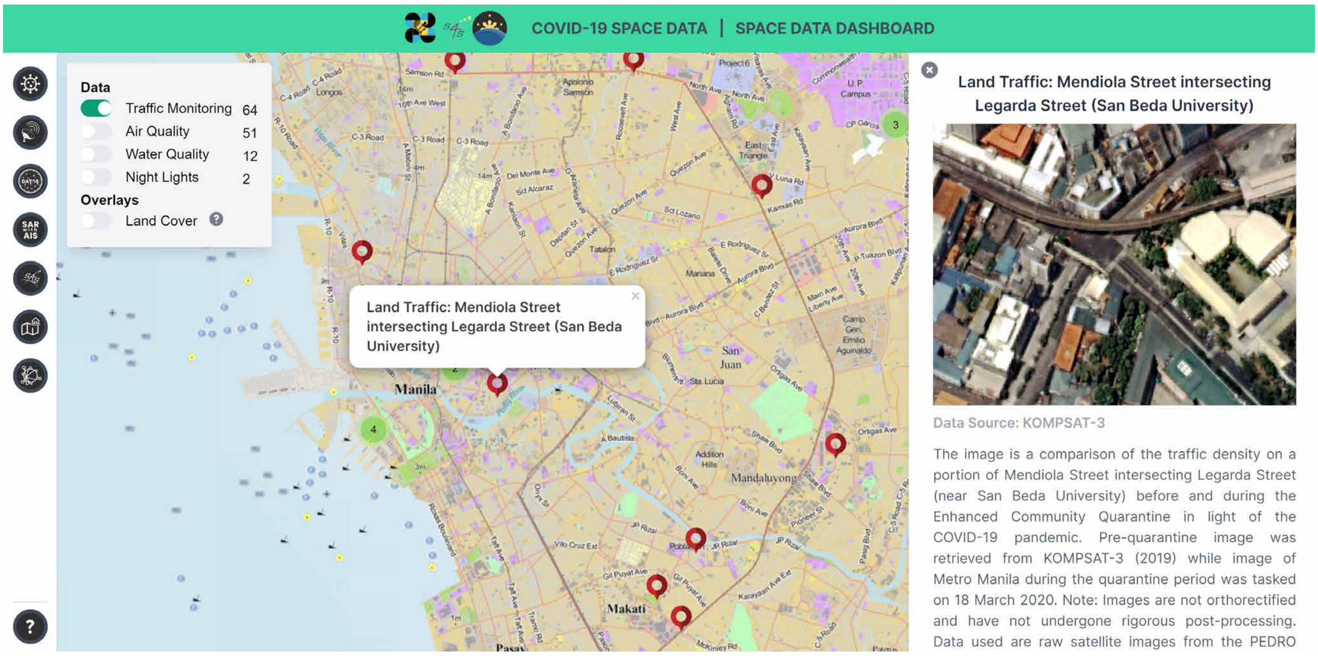
The country's increasing vulnerability to climate change has highlighted the need for PhilSA to collect readily accessible and available data on climate-related conditions, using a combination of sovereign satellites, curated satellite data sources, ground stations and high performing computing systems.

The Space Data Dashboard provides this publicly available data on an online web platform. To help the public understand the maps and data, PhilSA hosts an annual Space Data Dashboard Media Workshop where people, including journalists, are taught to navigate and produce articles using space data.

Figure 2.38: Philippine Space Agency presented the High-Resolution Telescope data taken by the Philippines' Diwata-2 satellite for Apo Reef, at United Nations Conference Center in Bangkok, Thailand, 31 August 2022

Source: ESCAP, Space Applications Section (SAS), 2022.

Figure 2.39: PhilSA Space Data Dashboard



Source: Philippine Space Agency (PhilSA), "Traffic Monitoring: Space Data Dashboard". Available at https://philsa.gov.ph/spacedata/project/covid19 (accessed on 13 September 2022).

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3. Singapore: Virtual 3D platforms

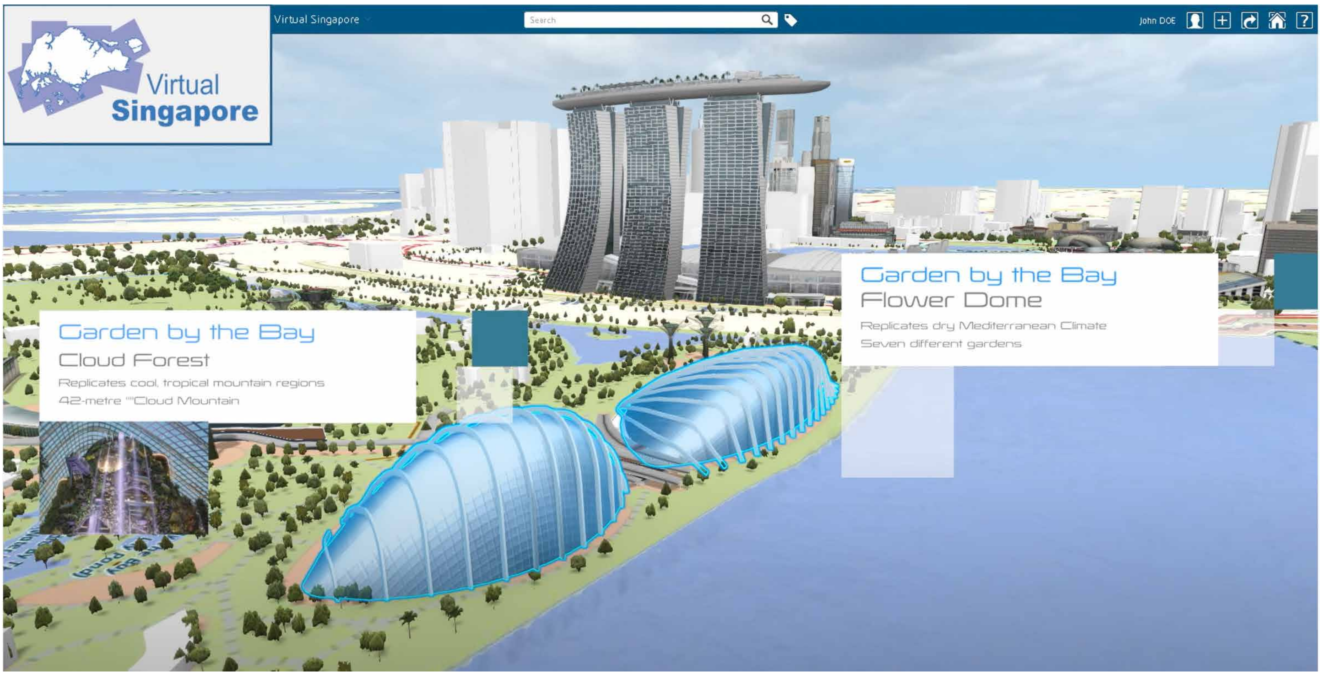
Virtual Singapore is a dynamic 3D city model and collaborative data platform which is used for planning and innovation by the public, private, and research sectors. Virtual Singapore creates a ‘digital twin’ of Singapore through 3D maps and geospatial data which, when completed, will serve as the authoritative 3D digital platform. This will enable users from different sectors to develop and use sophisticated tools and applications for different services, planning, decision-making, research and technology to solve emergency and complex challenges (Figure 2.40).

This project is co-led by the National Research Foundation (NRF), the Singaporean Prime Minister’s Office, the Singapore Land Authority (SLA) and the Government Technology Agency of Singapore (GovTech).

Virtual Singapore will include semantic 3D modelling comprising of detailed information of landscapes, including material representation of geometrical objects, texture, terrain attributes of landscape and infrastructure, including vegetation, water bodies, transportation facilities, etc. Models of buildings not only encode the geometry but also include detailed attribute information, such as walls, floors, and ceilings, as well as building material, such as granite, sand and stone.

This intelligent information platform will leverage big data, and allow users to derive insights, develop solutions and run simulations by creating visual models and realistic large-scale scenarios. For example, users will be able to use the platform to simulate crowd control, evacuation measures, planning scenarios for municipal services, pedestrian flows, flood risk analysis, transportation, renewable energy, environmental management, emergency services, network coverage, science and research and many others.[73]

Figure 2.40: **Virtual Singapore platform**



Source: National Research Foundation, Prime Minister’s Office Singapore, “Virtual Singapore”, 2021. Available at https://www.nrf.gov.sg/programmes/virtual-singapore

Data management and frameworks

4. Indonesia: Digital platforms

As part of Indonesia's on-going space strategy, several government departments have developed a number of online geospatial platforms within different sectors. These include:

- Satellite Disaster Early Warning System (SADEWA)

The SADEWA platform provides real time satellite-based observations and predictions of extreme rainfall and potential hydro-meteorological disasters to support disaster management in Indonesia.

- Maritime Information System (SEMAR)

The development and operation of the SEMAR platform was undertaken to improve shipping safety based on satellite observation and the atmospheric-ocean model. The platform provides real-time satellite-based observations and predictions of oceanic and atmospheric conditions in Indonesia to support marine safety and fish production. In addition, the platform provides information on potential fishing grounds and location of ships.

- Indonesia Atmospheric Composition Information System (SRIKANDI)

The SRIKANDI platform provides real time satellite-based observations and predictions of atmospheric composition and air quality to support environmental and forest fire management over Indonesia. In addition, development and operation of the SRIKANDI is based on satellite data and the atmospheric chemistry model.

- Indonesia Seasonal Forecast Information System (KAMAJAYA)

The KAMAJAYA platform is based on satellite data and atmospheric models to support drought monitoring and agricultural management.

- Indonesia Climate Change Information System (SRIRAMA)

The development and operation of the SRIRAMA is based on space observation and climate models to improve climate resilience. The SRIRAMA provides a 100-year climate projection for the Indonesian region. The platform provides long term model-based climate change projection over Indonesia to support national, regional and urban planning and development.

5. Thailand: Digital transformation

Thailand's National Space Master Plan (2023-2037)

Thailand is drafting the National Space Master Plan (NSMP) to pursue the new space economy as an opportunity for the country to promote socioeconomic development and national security. Because of Moore's law, reusable rockets, and the rideshare business model, space technology is becoming more affordable, creating a competitive advantage in both the private and public sectors and is fundamental for the new global competitive prowess as space is dual-use for civilian and defence. Therefore, NSMP aims to achieve three major outcomes: national security; prosperity; and sustainability. To achieve these outcomes, NSMP will cover the following agendas:

- Thailand will invest in space infrastructure, and investments can be in the form of completely owned government enterprises or joint partnerships with the private sector. Both sectors can benefit from space infrastructure, both hard and soft;

- Thailand will expedite space innovation research and development for commercial use and support high-level space education and educational institutions. The private sector will be more active in Thailand's space research and development;

- To pursue advanced space missions, Thailand will require space specialists and knowledge workers who can integrate multidisciplinary scientific knowledge. So, human capital is a vital factor. Furthermore, the new space economy necessitates space education with human experience and scientific knowledge;

- International collaboration is essential and crucial in space economic development because space technology uses advanced science and knowledge, which can be transferred from more advanced countries via an international cooperation network. Moreover, international trade agreements could bring commercial values to the nation; and
- Thailand aims at reforming its laws and regulations to facilitate the private sector to pursue the new space economy, and holistically utilize all resources from all agencies for the same national space agendas.

Thai Government's Big Data Institute

Thailand established the Government Big Data Institute (GBDi), in 2019, to promote the analysis and management of big data for state organizations. The institute is expected to be renamed to National Big Data Institute (NBDi) and expanded in terms of human resources by the end of 2022. The institute aims at enhancing cyber security and data analytics capability in the country, and is poised to play a crucial role in the data analysis of the government's policymaking.

The GBDi works in collaboration with other government agencies on projects focused on big data and is among the three core drivers striving for digital transformation development in Thailand. The other two institutes are the Startups Institute and the Internet of Things (IoT) Institute. The projects initiated by GBDi are dedicated to the design of IT architecture for the public health sector, development of the tourism sector, with platforms and applications and comprehensive virtualization dashboard for the agriculture sector implemented via design of big data architecture.[74]

6. South-East Asia Open Data Cube: A new initiative supporting climate smart innovation[75]

The Commonwealth Scientific and Industrial Research Organisation (CSIRO) and Geoscience Australia are supporting South-East Asia in the growth and implementation of space application products, namely Earth observation.

Both agencies have developed the Earth Observation for Climate Smart Innovation project (EOCSI), which aims to leverage space-based data and analysis using Open Data Cube technology. This will be powered by the CSIRO's Earth Analytics Science and Innovation hub (EASI), and used to engage local government, business and education institutions to take advantage of Earth observation for the development of climate smart applications.

Leveraging the Open Data Cube technology, which is already implemented in several regions, notably Africa (Digital Earth Africa), provides users with online access to large quantities of open-source space-based data. As this data is hosted online, it means that users do not need local storage or supercomputing infrastructure, bridging gaps within countries that may not have this infrastructure available.

By developing this data cube, countries have access to adequate information to use different geospatial tools and conduct analysis, allowing for better understanding of economic, environmental and social spheres. Users can use the platform to analyse changes within all fields, such as managing natural resources, examine urban development trends, understand food security challenges, and address climate adaptation, forest management (including deforestation), and coastal degradation, and examine the energy and transport sectors.

Theme 7 - Space applications for COVID-19 management and response

3 GOOD HEALTH AND WELL-BEING

During the COVID-19 pandemic many countries leveraged space applications and geospatial data in multiple ways. Many people saw the increased usage and importance of space-derived data during this time, especially for monitoring and visualization purposes, not only within national and regional decision-making but also for public data dissemination tools

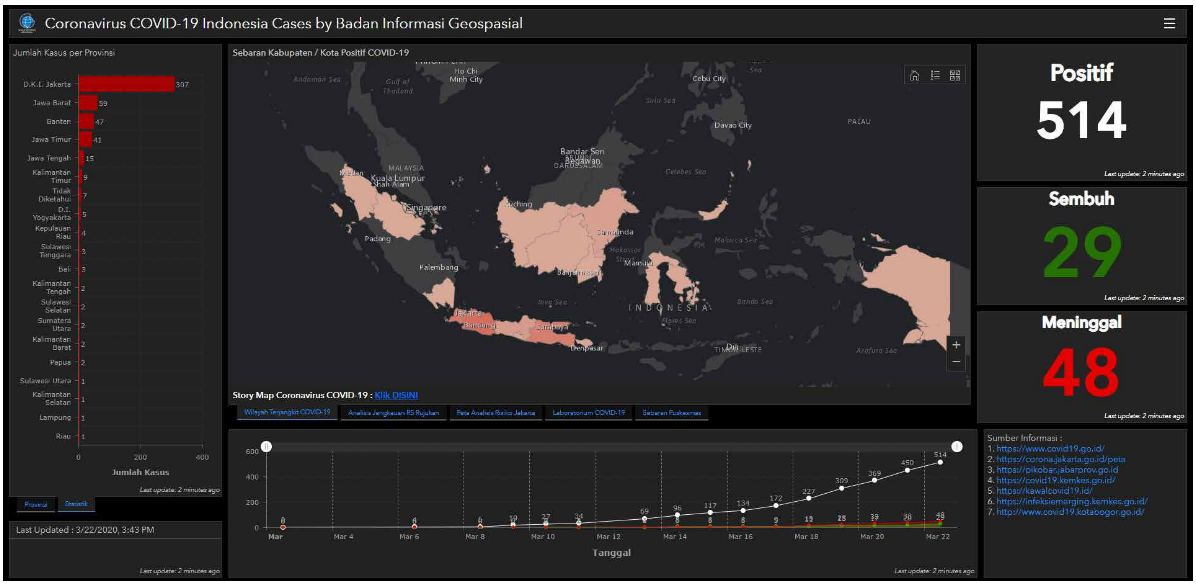
1. COVID-19 online dashboards and monitoring through geospatial data

Many countries utilized space-based applications and geodata to deploy online web applications and dashboards for public use. These dashboards were used as a visualization and communication tool to show live, updated statics and data about the COVID-19 situation within different areas. These online dashboards are updated regularly with new information, presenting the progress of the pandemic as it changes over time.

Indonesia: Distribution map of COVID-19

The Geospatial Information Agency in Indonesia released the online COVID-19 distribution map.[76] Through this online interactive web-map users are able to monitor the distribution area of COVID-19, along with data charts and spatial analysis of the COVID-19 distribution in certain regions (Figure 2.41).

Figure 2.41: COVID-19 Dashboard for Indonesia



Source: Badan Informasi Geospasial, "Monitor COVID-19 Distribution Through Maps", 21 September 2022. Available at https://www.big.go.id/en/news/2020/03/23/monitor-covid-19-distribution-through-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.

Malaysia: Creating a common, national, real-time view of COVID-19[77]

The COVID-19 pandemic represented the largest response and recovery operation Malaysia has ever seen. As one of the Government's most important national agencies, the Department of Survey and Mapping Malaysia (JUPEM), played a key role in effectively managing the country's crisis. To help keep communities safe, JUPEM developed a COVID-19 digital hub in the form of an online dashboard application, to provide all government agencies with access to a common view of the unfolding situation.

The COVID-19 digital hub uses advanced geospatial technology to provide a real time map of daily cases, quarantine centres, lockdown procedures and community demographics. The digital hub combines multiple datasets, including daily statistics from the Ministry of Health, JUPEM topographic data, demographic data from the Department of Statistics and geospatial data from the National Geospatial Centre. Through this system, decision makers can access accurate and current information and closely collaborate on policy development and response recovery strategies.

Philippines: COVID-19 digital innovations

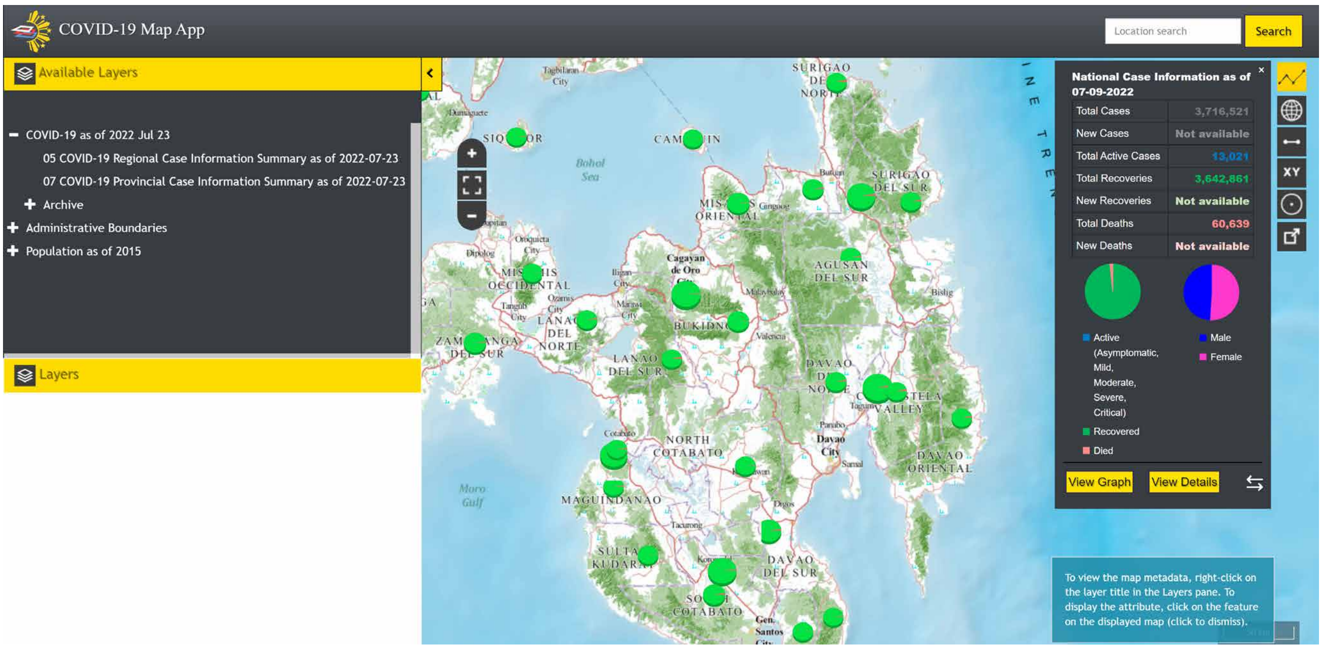
In the Philippines, the National Mapping and Resource Information Authority (NAMRIA), in collaboration with the Department of Health (DOH) launched the COVID-19 Map App,[78] a collection of up-to-date digital maps on the COVID-19 pandemic. The COVID-19 Map App features geospatial data on COVID-19 testing facilities and case information on national, regional, provincial, and city/municipal level, including health status and sex-disaggregated data on patients (Figure 2.42).

The Philippines also launched several other innovative online applications, that use geodata and space applications, to help fight the spread of COVID-19.[79] These include:

- Several contract-tracing applications and systems. These use location mapping and matching to help in contact tracing infected individuals;

- Personal health assessment and monitoring tools. These applications help mitigate community transmission by getting people

Figure 2.42: COVID-19 Map App Screenshot of the platform



Source: COVID-19 Map App. Available at https://geoportal.gov.ph/gpapps/covidapp. Accessed on 13 September 2022.

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to monitor and evaluate their health status in their own home. This helps to determine if people need further medical care;

- Goods and supplies delivery systems. These applications aim to ensure that communities can access a steady supply of goods and services sold in local stores.

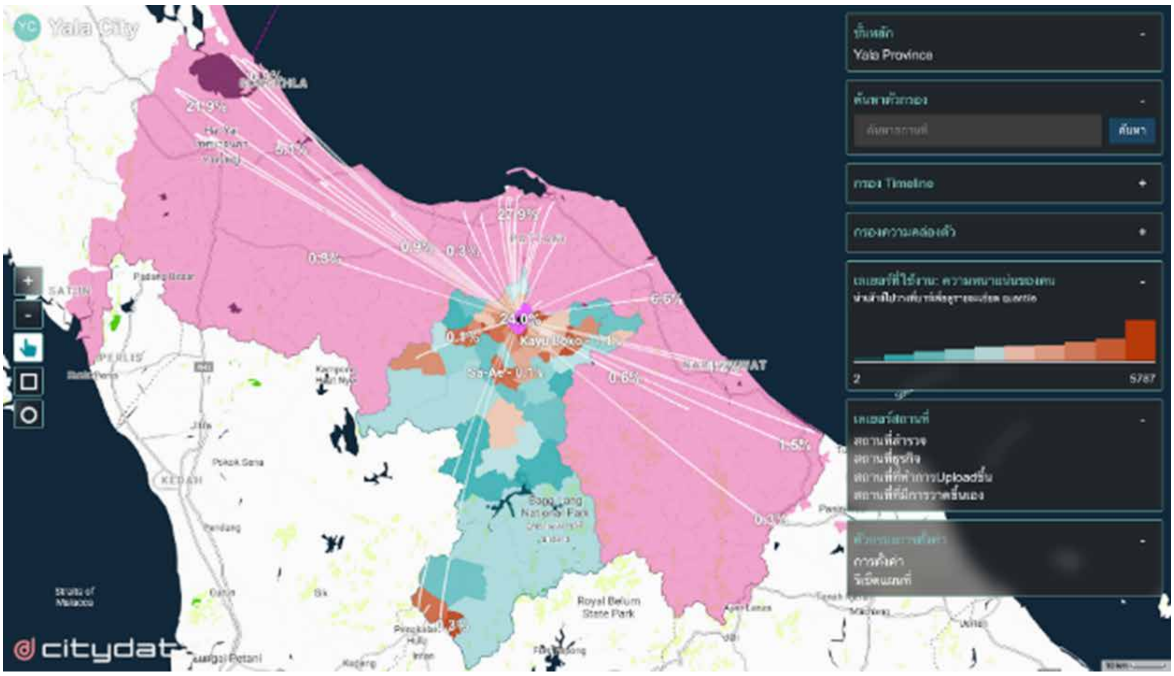
Thailand: Mobility big data and artificial intelligence (AI) for public health[80]

The Yala Province Municipality, in Southern Thailand, is the first administrative zone in Thailand to harness mobility big data and movement intelligence to monitor the spread of COVID-19. In August 2021, the Digital Economy Promotion Agency (DEPA) together with the Mayor of Yala Province partnered with CITYDATA.ai to create an online platform, CITYDASH, a self-serve map-based dashboard to track and monitor mobility data relating to the COVID-19 situation. The CITYDASH platform has been rolled out in over 1500 global cities, to provide them with powerful apps and tools to leverage geospatial data, big data and AI.

The CITYDASH platform aggregates and analyses crowdsourced data on mobility to identify the density and movement patterns across the region. This data analysis quantifies mobility patterns and measures travel between different areas, helping to make decisions on lockdowns. The Mayor of Yala Province ran digital surveys using time series, both before and after each lockdown. The results confirmed that people are willing to cooperate and comply with public health mandates.

This methodology and good practices put in place by Yala Province, in collaboration with CITYDATA, demonstrates the uses of geospatial data, big data and machine learning within the mobility sector, a practice that is customizable for other provinces across Thailand (Figure 2.43).

Figure 2.43: CITYDASH platform for Yala Province Thailand



Source: CITYDASH, 2022. Available at: https://beta.citydata.ai/

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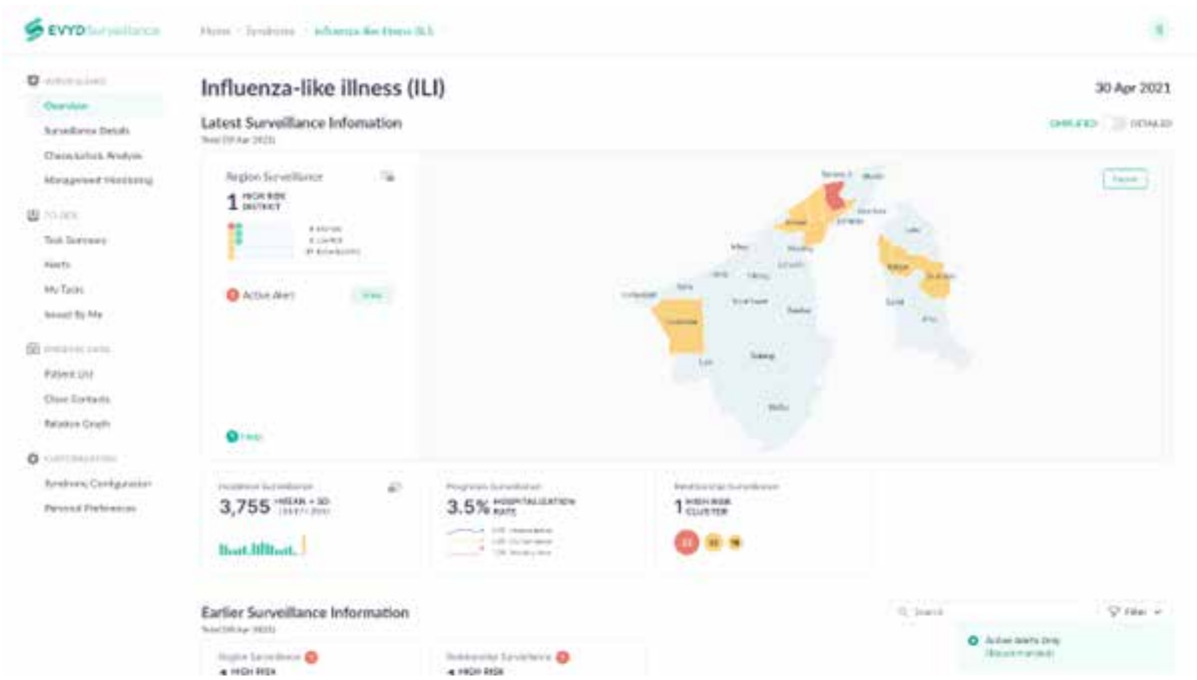
2. Brunei Darussalam: EVYD technology to support ASEAN digital public health

In 2021, the Special Ministerial Conference for ASEAN Digital Public Health,[81] was held by the Ministry of Finance and Economy, and the Ministry of Health in Brunei Darussalam, the Brunei Investment Agency, and Temasek Foundation which co-organized the conference to highlight the urgency for ASEAN leaders to collaborate and strategize viable and sustainable solutions to build resilient healthcare systems that can withstand future challenges.

During the conference, a healthcare technology company headquartered in Brunei Darussalam and Singapore, formally launched a knowledge hub. It is a community platform that aims to engage and connect key stakeholders including policymakers, health authorities, researchers, academia, NGOs, philanthropies, and industry experts in the public health-care sector. Using big data and artificial intelligence technologies, the knowledge hub was able to compute sharper insights and outcomes for public health data. Through this knowledge hub platform, the use of innovative digital technologies to aid in public health policymaking is promoted to ensure that countries across the region are well prepared to face public health challenges.

The knowledge hub includes an online dashboard to track and monitor the emergence and spread of over 30 infectious diseases in real-time (Figure 2.44). This dashboard allows people to investigate and respond to potential health threats timely through active syndromic surveillance. The platform also helps to manage epidemics dynamically with the simulation and optimization platform with real-time synchronization and feedback. It informs the formulation of targeted containment strategies quickly through automated multidimensional contact tracing.

Figure 2.44: **EVYD Knowledge Hub platform**



Source: EVYD Platform. Available at https://www.evydtech.com/solutions/evydence-operating-platform/ (accessed on 13 September 2022).

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3. Viet Nam: Mobile application to monitor COVID-19 situation[82]

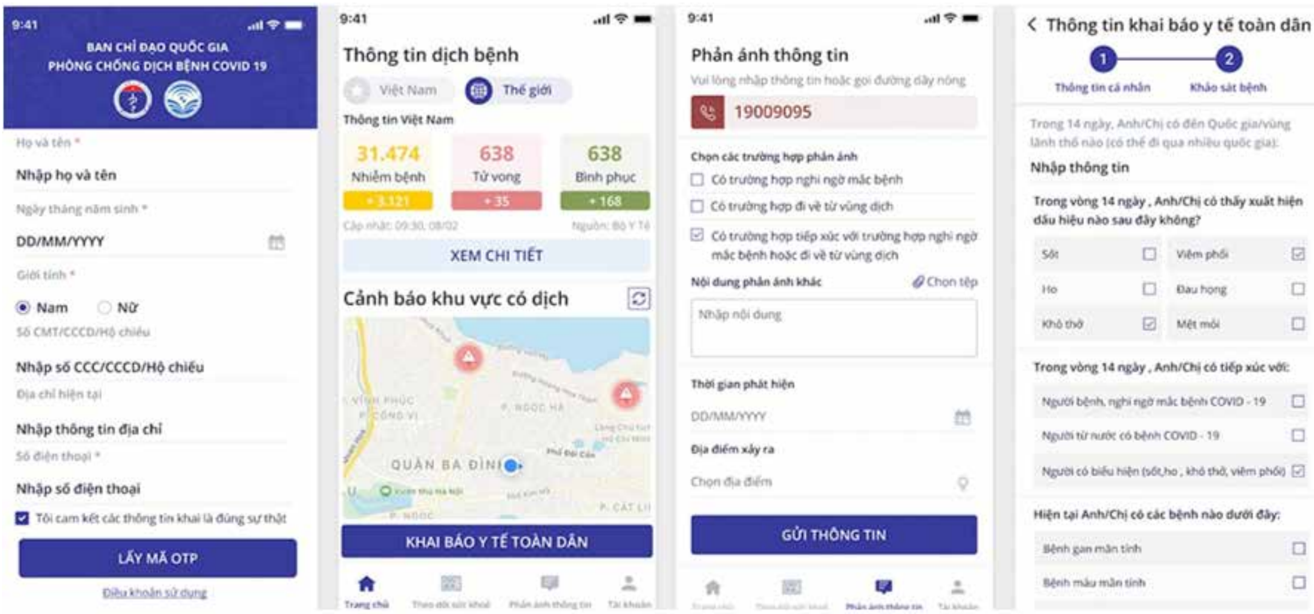
Viet Nam has long maintained robust systems to collect and aggregate public data, and in 2009 the country shifted to a near real-time, geospatial web-based system. In recent years, particularly since 2016, Vietnamese hospitals are required to report to a central database for notable diseases within 24 hours. This ensures that the Ministry of Health can use the data to track epidemiological developments across the country.

In 2018, Viet Nam, in collaboration with the United States Center for Disease Control and Prevention (CDC), implemented an "event-based" surveillance program. Such event-based surveillance helps to track trends and patterns, identify clusters of people who have similar symptoms, and detect an emerging outbreak based on reporting cases around location data. This reporting and notification system helps to encourage members of the public, specifically those within the medical field, to report public health events.

During the COVID-19 pandemic, the Ministry of Health and the Ministry of Information and Communications created the NCOVI application, to assist people in making voluntary medical declarations, thereby contributing to the prevention and fight against COVID-19 (Figure 2.45). The application also includes a map of detected cases and clusters of infections, allowing users to declare their own health status, report suspected cases and watch real-time movement of people under quarantine. The app was downloaded by over 20 million users within the first six months of usage.

Because of already existent infrastructure, in the health-care system and centralization of data, Viet Nam was able to control the spread of COVID-19, acting quickly and keeping case numbers low.

Figure 2.45: Screenshot of NCOVI application



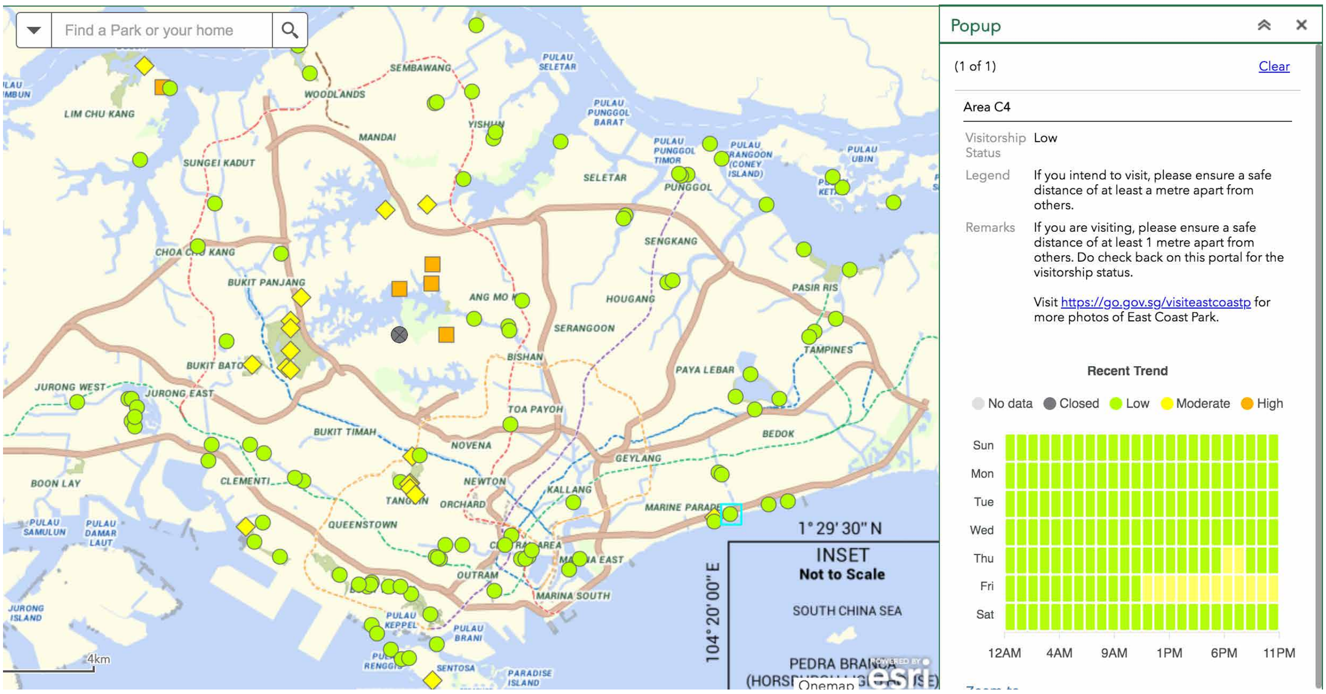
Source: Vietcetera, "In a nutshell: NCOVI application was officially launched, together to make health declaration for the whole population", 3 March 2020. Available at https://vietcetera.com/vn/ung-dung-ncovi-chinh-thuc-ra-mat-cung-thuc-hien-khai-bao-y-te-toan-dan.

4. Singapore: Mapping risks in parks

In Singapore, during the COVID-19 pandemic, the National Parks Board (NParks) and the Government Technology Agency (GovTech) created Safe Distance @ Parks,[83] an online interactive web map to help residents assess risk before going to their favourite parks. The interactive map shows real-time visitor status at local parks, helping residents understand how busy or crowded an area is, determining whether they should visit a given park.

This application leverages technology to support the community in safe distancing operations, allowing members of the public to look for a park near them and check visitor levels before leaving their homes. The app receives near real-time updates on crowd sizes and displays visitors marked by three colours: orange (high), yellow (moderate) and green (low). This type of digital innovation helps residents to stay active, while also maintaining a safe environment (Figure 2.46).

Figure 2.46: Screenshot of the Safe Distance @ Parks application



Source: GovTech. Available at https://www.tech.gov.sg/media/technews/safe-distance-at-nparks. (accessed on 28 September 2022).

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Conclusion

This chapter has highlighted numerous good practice examples where countries across South-East Asia are contributing to the six thematic areas, the Regional Road Map, the Plan of Action and the SDGs. Countries across the region are utilizing the vast array of space applications and geospatial data, from GIS methodologies to remote sensing satellite imagery, and making strides to bridge gaps and improve resilience.

However, this improvement is not occurring equally across the region and some countries still lack the capacity and technological development to digitally grow and expand, especially in terms of using space applications. Through regional mechanisms and initiatives, more countries can increase their knowledge and understanding of the usage of space applications and geospatial data from countries within the region. Chapter 3 takes on an analytical approach to review the best practices and lessons learned that were discussed in Chapter 2. It highlights clear cross-cutting examples of how geospatial data can be made more available, accessible, affordable, and actionable.

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Annex

Thematic Area	Sub-theme	Practice Number	Country	Practice Title
Disaster Risk Reduction and Resilience	Innovation in disaster preparedness and management	1	Asia	Pan-Asia Partnership for Geospatial Air Pollution Information (PAPGAPI)
		2	ESCAP/ UNOSAT	Risk and Resilience Portal: An initiative of the Asia-Pacific Disaster Resilience Networki
		3	UNOSAT	FloodAI: Available for multiple countries in South-East Asia
	Risk reducation, disaster assessment and emergency response	4	Viet Nam	Viet Nam Natural Disaster Monitoring System (VNDMS)
		5	Indonesia	Remote sensing data to support disaster management
		6	Malaysia	Remote sensing to assess impacts of oil spill on mangrove forests
		7	Philippines	Utilizing ICT and geospatial applications for disaster preparedness
		8	Philippines	Digital twin technology for disaster response
		9	Thailand	ThaiAWARE – An early warning and hazard monitoring system
	Food production	10	Indonesia	Integration of deep machine learning with satellite data to map paddy rice production stages
		11	Philippines	The Philippine Rice Information System (PRISM)
	Climate Hazards	12	Singapore	Regional forest fires and haze
Natural Resource Managemet	Urban planning	1	Thailand	Geospatial platform for tracking and managing particle matter (PM2.5) using satellite imagery
		2	Cambodia	Application of Land Surface Temperature Analysis in Urban Green Spaces (UGS)
	Waste Management	3	ASEAN	Monitoring plastic waste
		4	Malaysia	Driving resilient and sustainable waste management
	Land use change and forest management	5	FAO	Agricultural Stress Index System (ASIS)
		6	Singapore	Regional Land Cover Mapping and Land Cover Change Studies
		7	Philippines	The Multispectral Unit for Land Assessment (MULA)
		8	Malaysia	Utilization of remote-sensing technology for deforestation identification
		9	Thailand	Forest Resource Monitoring System to identify suspected deforestation
		10	Thailand	Forest Industry Organization Geospatial Information Portal
	Water resource management	11	Philippines	Aquatic ecosystems and water resources management
	Marine ecosystems and sustainable fisheries	12	Malaysia	MyMarine GeoHub - Innovative Marine Spatial Data Infrastructure portal
		13	Singapore	GeoSpace-Sea – a national Marine Spatial Data Infrastructure
		14	Thailand	Geospatial information for sustainable fisheries resources management
		15	ASEAN	Hotspot analysis of coastal aquaculture

Thematic Area	Sub-theme	Practice Number	Country	Practice Title
Connectivity	Transport and traffic systems	1	Cambodia	Geospatial modelling for emergency service road access to rural access
		2	Malaysia	Selangor Malaysia: Collecting data for smart decision-making
		5	Singapore	Traffic Watch makes use of spatial data to tackle road congestion
	Access to the internet	3	Philippines	Free public Internet access programme
		6	Viet Nam	Building the country's largest data centre
		Box 1	Singapore	Singapore Space and Technology Limited
Social Development	Poverty and vulnerable groups	1	Indonesia	SDG monitoring
		2	Thailand	Creating a database of low-income communities from aerial imagery
		3	Malaysia	An innovative humanitarian activities mapping
		4	Singapore	Innovation challenge to design device to better track location of people with special needs
		Box 2	ESCAP	ESCAP Statistics Division (ESCAP-SD): Geospatial Guides
	Health management	5	Cambodia	Satellite imagery usage for detecting hazardous areas
		6	ASEAN	Increasing the understanding of dengue vulnerability
	Contamination and pollution	7	Singapore	Monitoring health impacts of air quality using satellite data
Energy	Renewable energy infrastructure site appraisal	1	ESCAP	Expert World Group on Universal Access to Modern Energy Services
		2	Global	The Renewable Energy Zoning Tool (REZoning)
		6	Thailand	Renewable energy projects
		4	Malaysia	Identifying Potential Wave Energy Locations using GIS
	Mapping energey consumption	3	Cambodia	Modelling electricity consumption using remote sensing night imagery
		5	Philippines	Cloud-based Monitors and Electronic Sensors (e-sensors) for Energy Conservation
Climate Change	Collaboration to build capacity towards climate resilience	1	ESCAP	Strengthening geospatial capacity in Lower Mekong countries
		2	ESCAP	Building institutional capacity for the use of integrated spatio-temporal data in local SDGs monitoring and decision-making
	Innovative tools and methods for climate related mapping	Box 3	ASEAN	PRISM, a Climate Risk Monitoring platform to facilitate risk-informed decision making
		3	ASEAN	SERVIR-Mekong utilizing satellite data for climate response
		4	Cambodia	Digital GIS Climate Change Toolkit
		5	Singapore	New Urban Planning GIS Tool to Improve Urban Climate Resilience
		6	Thailand, ASEAN	Integrated Climate Observing System
	Risk mapping	7	Indonesia, Viet Nam	Monitoring mangroves using remote sensing data
		8	Singapore	Use of satellite data to estimate sea level changes

<table>
<tr><th>Thematic Area</th><th>Sub-theme</th><th>Practice Number</th><th>Country</th><th>Practice Title</th></tr>
<tr><td rowspan="6">SPACE + Trends and Innovative Technologies</td><td rowspan="3">Geospatial innovation, data sharing platforms and integration technologies</td><td>1</td><td>ASEAN</td><td>Space+ promotion across young scientists in ASEAN</td></tr>
<tr><td>2</td><td>Philippines</td><td>PhilSA integrated network for space-enabled actions towards sustainability</td></tr>
<tr><td>3</td><td>Singapore</td><td>Virtual 3D Platforms</td></tr>
<tr><td rowspan="3">Data management and frameworks</td><td>4</td><td>Thailand</td><td>Digital Transformation</td></tr>
<tr><td>5</td><td>Indonesia</td><td>Digital platforms</td></tr>
<tr><td>6</td><td>ASEAN</td><td>South-East Asia Open Data Cube: A new initiative supporting climate smart innovation</td></tr>
<tr><td rowspan="4">COVID-19</td><td>Monitoring and responding to COVID-19</td><td>1</td><td>ASEAN</td><td>COVID-19 online dashboards and monitoring through geospatial data</td></tr>
<tr><td rowspan="3">Innovation for COVID-19 response</td><td>2</td><td>Brunei Darussalam</td><td>Evyd Technology in to support ASEAN Digital Public Health</td></tr>
<tr><td>3</td><td>Viet Nam</td><td>Mobile application to monitor COVID-19 situation</td></tr>
<tr><td>4</td><td>Singapore</td><td>Mapping Park risk</td></tr>
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Chapter 3

Best practices for using geospatial data

Chapter 2 described over 60 good practices of the use and application of geospatial data and information, from across several countries in the South-East Asian region, giving readers a comprehensive overview of how different space-based applications and methodologies have been used across the subregion. The selection of these good practices was based on showcasing examples that demonstrated the innovative and unique uses of space applications, and provided clear benefits for users.

In an effort to be inclusive, the good practices were selected from across all South-East Asian countries, where possible, with the aim to highlight the wide range of space-based activities being undertaken. However, it is also important to note that the selection of practices was limited to those submitted to the ESCAP secretariat and/or were readily available online. Therefore, the examples collected may be unequally distributed across countries within the South-East Asia region.

The examples are proof of the steady progress that countries within the Asia-Pacific region are making on the uses of geospatial information and space applications. This has been demonstrated by the commitment, made by member States, to contribute to the Asia-Pacific Plan of Action on Space Applications for Sustainable Development (2018–2030) (Plan of Action). The 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. All of the good practices described in Chapter 2 are associated with the thematic and sub-thematic areas of the Plan of Action. The focus, in particular, was on those advancements that occurred between 2018 – 2022, which contributed directly to Phase I of the implementation of the Plan of Action. Overall, the examples highlighted the value of and the benefits that space applications and geospatial data provide to countries, particularly in the economic, social and environmental sectors.

Of all the examples of good practices discussed in Chapter 2, a few prime examples have been selected for discussion for this present chapter based on the 4As, 4Ps and 3Is framework that was highlighted in the 2020 edition of the ESCAP publication, *Geospatial Practices for Sustainable Development in Asia and the Pacific 2020: A Compendium*. The Compendium highlighted that geospatial data should be **accessible, available, actionable, and affordable (4As) to benefit people and inform practices, processes, and policies (4Ps)**. The concept of the 4As and 4Ps arose from the analysis of over 100 good practices, in 2020, along with the seven key factors for success and recommendations. Furthermore, geospatial data **integration** and **innovations**, and **inter-disciplinary** geospatial data usage **(3Is)** have also been added to comprehensively assess the best geospatial practices.

Box 3.1: Database of Good Practices

In addition to the examples highlighted in Chapter 2, several good practice examples were collected and/or submitted, including many from outside South-East Asia. In recognition of the need to track the implementation of the Plan of Action, and the requirement to collect and store identified good practices for both knowledge-sharing and future publications, ESCAP has developed a Database of Good Practices and an associated dashboard to meet these needs.

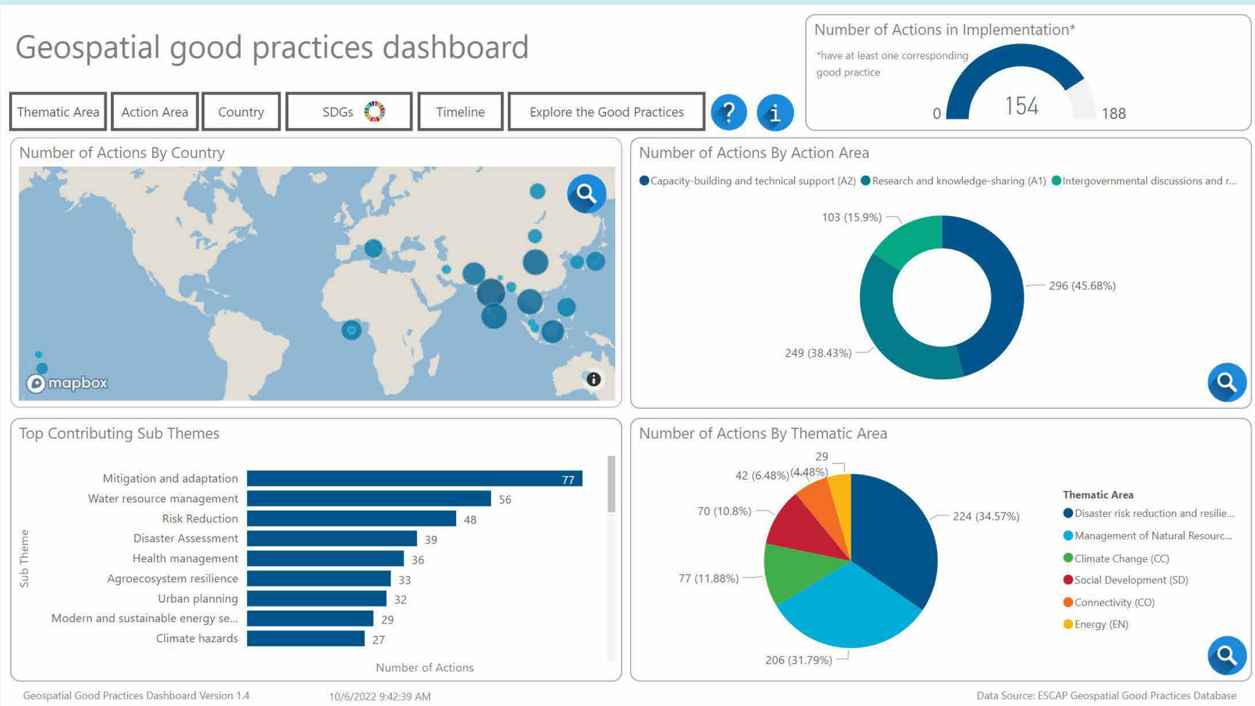
The aim of this database is to develop and implement a uniform way of collecting, storing, and reporting good practices for space applications. The data that is collected through this project will be used for a variety of purposes. These include:

- Reporting on progress and actions taken towards the set goals of the Plan of Action using a developed dashboard that provides an overview of the current status;
- Creating a space where good practices from around the region can be stored and shared through an accessible, easy-to-use online portal;
- Creating an accessible and easy-to-use portal that is available at any time to upload new good practices.

These practices are organized in an online, interactive dashboard, where users can filter between countries, regions, themes, sub-themes and actions. The online dashboard is updated regularly as new good practices are submitted or collected, and is a datahub that stores all the information in a central location for users to access overtime. More importantly, the dashboard will allow countries to identify where similar mechanisms are being used in the region, in order to increase regional and subregional coordination and capacity-building.

The dashboard can be accessed at: United Nations, Economic and Social Commission of Asia and the Pacific (ESCAP), Online database of geospatial practices and dashboard for reporting on the implementation of the Asia-Pacific Plan of Action on Space Applications for Sustainable Development (2018-2030). Available at https://www.unescap.org/kp/2022/online-database-geospatial-practices-and-dashboard-reporting-implementation-asia-pacific#

Figure 3.1: Screenshot of the Database of Good Practices Dashboard



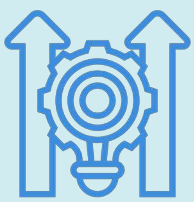
Source: ESCAP, Space Applications Section (SAS), 2022.

The 4As and 4Ps framework for implementing Phase I of the Plan of Action

The 4As and 4Ps framework recognizes that countries, in the Asia-Pacific region, are at varying stages of leveraging advances in space technology and digital innovations because of infrastructural, financial, policy, and other constraints. In this regard, it is essential that, moving forward, geospatial data and space applications are developed in line with the framework of the 4As and 4Ps.

Across South-East Asia, countries are also at varying stages of developing space applications, with many countries leveraging data, including open source, for the development of digital innovations and tools across all sectors. Therefore, the 4As and 4Ps framework formed the basis for selecting and analysing the prime examples of best practices from all the examples highlighted in Chapter 2. Such analysis of best practices is vital in showcasing examples that provide clear pathways for countries to replicate at the national level, so as to tap into their full potential.

Table 3.1: Definitions of the 4As

	**Available:** To make geospatial data widely available, it first needs to be easily accessible. Once accessed, countries can make data available through national platforms and databases, whether public or private. Data can also be made available at the regional and international levels through data-sharing mechanisms. Capacity-building and open-source data initiatives can also help to ensure the timely creation of data, increasing data availability.
	**Accessible**: Geospatial data needs to be accessible within countries and between countries. Within countries, geospatial data can be made accessible through sharing data between ministries and government organizations, which will help to streamline geospatial and statistical data across all government sectors. Between countries, geospatial data can be accessed through specific data programmes, such as regional mechanisms.
	**Affordable:** To ensure geospatial data can be actionable, geospatial data needs to be affordable, to ensure that all countries regardless of their GDP can have financial resources to **access** and analyse **available** data. Making data affordable can be done through open-source, regional and international initiatives, such as data sharing and capacity-building programmes.
	**Actionable:** Once data is accessible, available and affordable, it will then become actionable. This means that countries can practically utilize geospatial data by putting data into action to support evidence-based decision-making. In addition, countries can integrate geospatial data with other space-based data, ground data and statistical data. Combining data will allow it to be used to its full potential.

While the aim of countries is to achieve the 4As, they may lack adequate knowledge and capacity to use geospatial data to its full potential. In this regard, regional platforms and mechanisms, such as ESCAP's Regional Space Applications Programme (RESAP), provide critical support in helping countries make geospatial data become accessible, available, actionable and affordable.

Once countries have the ability to achieve the 4As, geospatial data will then begin benefiting people, informing practices, processes and policies (4Ps). Furthermore, geospatial data integration, geospatial data innovations, and inter-disciplinary geospatial data usage (3Is) have also been added to comprehensively assess the best geospatial practices (Figure 3.2).

The 4As, 4Ps and 3Is framework forms the methodology for shortlisting the best practice examples discussed in this chapter.

Figure 3.2: Geospatial data should be accessible, available, actionable and affordable to benefit people and inform practices, processes and policies

Source: *Geospatial Practices for Sustainable Development in Asia and the Pacific 2020: A Compendium* (United Nations publication, 2020).

Highlighting Best Practices: Phase I of the Plan of Action

4A: Available, Accessible, Affordable and Actionable

4P: People, Practices, Processes and Policies

3I: Integration, Innovation and Inter-disciplinary

Many countries within the Asia-Pacific region, and specifically in South-East Asia, acknowledge the importance of implementing the Plan of Action, Regional Road Map and the 2030 Agenda for Sustainable Development (SDGs). In this regard, several countries have been developing space applications and geospatial data with the aim that geospatial data should be accessible, available, actionable and affordable (4As) to benefit people and inform practices, processes and policies (4Ps). These practices have been integrated into innovative digital programmes and are cross-cutting and interdisciplinary (3Is).

Based on the 4As, 4Ps and 3Is framework, a few key examples of best practices have been shortlisted and analysed from over 60 examples that were described in Chapter 2. To see the full list of examples, please see Chapter 2.

Accessible

1. Indonesia: Making data accessible for SDG monitoring

Countries within the Asia-Pacific region have been consistently increasing their efforts to promote the use of geospatial information applications in local governments, especially for monitoring the SDGs, and integrating statistical data. Recently, experts from China and the Committee of Experts on Global Geospatial Information Management shared their experiences using geospatial tools where a data-driven and evidence-supported approach was created for SDG local monitoring. This was undertaken for a pilot project in Deqing, China,[1] where a geospatial framework that produced valuable results on SDG local monitoring was created, including a cooperation network able to focus resources on major tasks, and provide significant guidance for local development policymaking. These experts are providing technical assistance to the Governments of Indonesia and Thailand who are also using integrated spatio-temporal data to monitor progress in achieving the SDGs.

In Indonesia, experts have developed different space-based methods to identify and classify slum areas within the country, and are sharing this information on an open-access platform. Using a customizable method, modelled on the Deqing example, this model has been developed to integrate space-based data and non-georeferenced sectoral data. By performing geospatial analysis on available remote sensing data, low income/slum areas can be identified and datasets can be created. Once this data has been created, it can be accessed and shared across multiple government sectors. Combining this data with additional sectoral data, will further aid stakeholders and decision-makers to take necessary action and implement relevant policies. Furthermore, the availability and accessibility of the data, produced from the project, will support multiple government ministries. For example, the Ministry of Social Affairs can estimate the number of potential low-income recipients that are eligible for the government's social assistance programme.

This example demonstrates how regional mechanisms can help provide capacity-building between Asia-Pacific countries to increase geospatial sectoral data within national ministries. By creating satellite-derived data and making it more accessible, it can be used for timely situational analysis across multiple government sectors.

Thematic Area	SDGs
Social Development: Poverty, vulnerable groups 	

2. Regional: Making data accessible through COVID-19 portals

The last section of Chapter 2 described several examples from South-East Asia that highlighted how space applications contributed to the response and management of the COVID-19 pandemic. During the pandemic, many countries were pushed to leverage digital innovations in multiple ways, especially for data monitoring and visualization. This was prevalent in both national and regional decision-making, as well as for public data sharing and visualization.

After the John Hopkins COVID-19 dashboard was launched in January 2020,[2] many countries around the world followed suit and launched their own national or subnational dashboards to leverage geospatial data and applications to provide updated, on-demand statistics for their citizens. During the pandemic, these types of online data-sharing tools were vital in providing citizens with up-to-date information on the national situation. In addition to these online dashboards, counties also leveraged artificial intelligence (AI) and big data tools and created several monitoring and health apps. Such applications continued to be developed throughout the pandemic, and gave countries tools for monitoring cases and administering vaccines.

Indonesia, Malaysia, the Philippines, Brunei Darussalam, Thailand and Singapore all reported having data visualization platforms to report COVID-19 cases and the vaccination status of their citizens over the course of the pandemic. For example, Thailand created the COVID-19 iMap Dashboard, which was used to monitor cases within each province of the country.

Singapore also expanded on digital tools to create an interactive, live web map showing different park hotspots around the country. This tool was useful for citizens to see which parks and green spaces were more or less populated when trying to social distance and avoid large crowds.

Such data innovations, from countries across South-East Asia, are examples of the rapid digitalization that countries adopted in order to keep pace with the requirements of the evolving pandemic, and keep policymakers adequately informed for response and management. This was achieved by making geospatial data accessible at the local, national, regional and international level.

Thematic Area	SDGs
COVID-19 **Social Development:** Health management, vulnerable groups 	

3. Thailand: Sectoral data accessibility

In Thailand, 20 government agencies are utilizing space applications and geospatial data to contribute to the Phase I implementation of the Plan of Action, registering a total of 36 actions across 6 thematic areas. The Geoinformatics and Space Technology Development Agency (GISTDA) serves as the main government sector which is responsible for applying advanced geoinformatics applications and space technology to fully enhance Thailand's development. GISTDA is the leader in driving the rapid development of the country's space economy and the effectiveness of achieving the SDGs. GISTDA emphasizes researching, developing, and building innovative GIS applications for businesses through collaboration between government agencies and private sector organizations.

Government departments, across Thailand, are leading with their innovative, digital platforms, which make a range of sectorial data available online. This is especially prevalent in the field of natural resource management, where several robust geospatial platforms have been launched that host and visualize data for public and sectorial use. For example, remote sensing, GIS and GNSS are being utilized in land-use classification and mapping of forest plantations under the Forest Industry Organization (FIO). The Department of Fisheries also leverages space applications through the Fisheries GIS Portal, a digital platform that hosts several geospatial data. The portal is used to manage natural resources, including aquaculture, to prevent ecosystem and environmental degradation, and that aquatic animal resources are plentiful and used sustainably.

Through GISTDA, Thailand continues to enhance its support, especially on geospatial data accessibility, through collaboration with the ESCAP secretariat and its member States, particularly by providing technical assistance and capacity-building through the ASEAN Research and Training Center for Space Technology and Applications (ARTSA) network.

The ongoing use and expansion of geospatial data across several government departments in Thailand demonstrates the vital impact that data accessibility has on policy and decision-making. Making data accessible through online data-sharing portals is a prime way for it to be disseminated both publicly and privately.

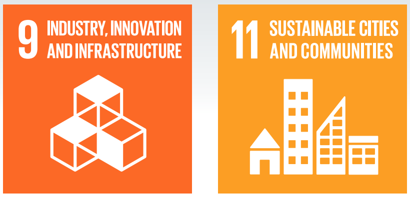
Thematic Area	SDGs
Space+ **Management of Natural Resources:** Marine ecosystems, sustainable fisheries, land use change 	

Available

1.Singapore: Making 3D data available through digital platforms

The creation of virtual 3D platforms in Singapore, namely Virtual Singapore, demonstrates how geospatial information, specifically 3D models and data, can be made readily available to urban planners and decision-makers. In Singapore, government ministries have collaborated on a project to collect and store 3D geospatial data and display it on a 3D authoritative digital platform. This platform will enable users across multiple sectors, such as urban planning and land management, to use sophisticated tools and applications to solve complex challenges.

Centralizing data and making it readily available is a key success factor which allows planners and decision makers to utilize geospatial data to make quick, data-driven decisions. The data is available for all sectors, and includes construction, engineering and design choices for buildings; disaster management planning; municipality planning; environmental management; and managing pedestrian flows, amongst others. This platform not only integrates geospatial data, but also additional sectorial data and ICT information across the country, thereby allowing users to access authoritative data. Singapore is planning to make this data available to the public, private and research sectors. Singapore's example demonstrates initiatives to make existing data, within multiple sectors, available across national, regional and international levels.

Thematic Area	SDGs
Disaster Risk Reduction and Resilience: Innovation **Management of Natural Resources:** Land use change **Connectivity for the 2030 Agenda for Sustainable Development:** Access to the Internet, and transport systems 	

2. Asia: The Pan-Asia Partnership for Geospatial Air Pollution Information (PAPGAPI)

The Pan-Asia Partnership for Geospatial Air Pollution Information (PAPGAPI), expanded on in Chapter 2, aims to boost the capacity of participating countries to monitor and manage air pollution through geospatial data and satellite applications.

Through this project, participating countries will be able to develop the capacity to use and analyse data from the Geostationary Environment Monitoring Spectrometer (GEMS), the first satellite sensor in the world that observes air pollutants. The outcomes of this project demonstrate clear regional cooperation which is at the forefront of innovative technologies. Countries across South-East Asia will be able to leverage the knowledge gained from this project to build capacity and develop training materials to access air pollution data which they may not have had the capacity to do before.

By making this data available, countries will be able to improve their operational monitoring of air pollution, while also tracking and monitoring climate changes over time, which will potentially inform critical policy recommendations and decision-making. Furthermore, pilot countries will be able to improve their capability to facilitate technology transfers, enable data-sharing and capacity-building, and engage in international cooperation initiatives on air pollution. This is a clear example of the integrated use of space applications and ground data, as well as of regional cooperation and capacity-building to make data more available to member States.

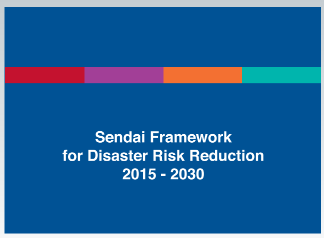
Thematic Area	SDGs
Climate Change: Mitigation and adaptation **Disaster Risk Reduction and Resilience:** Innovation **Social Development:** Contamination and pollution 	

3. Philippines: Data availability for disaster preparedness

The creation of the GeoRisk platform, in the Philippines, demonstrates how countries can make hazard, exposure and risk data readily available for public use to improve preparedness and resilience within the country. The GeoRisk platform enables users to access hazard and risk information, before, during and after a crisis.

Data availability is especially essential during a crisis, as time and resources are limited. Having a platform where usable data can be made available, on-demand is vital for taking timely action in emergency situations. The platform also makes essential geospatial data readily available in a synthesized location, which can be accessed nationwide.

This example demonstrates the potential of such a platform to act as a key tool and service for multiple government agencies to easily find reliable data when a crisis unfolds. Ensuring that data is constantly available and up-to-date, particularly when crisis situations unfold, is essential for quick disaster response and recovery.

Thematic Area	SDGs
Disaster Risk Reduction and Resilience: Emergency response, risk reduction, disaster assessment 	

Affordable

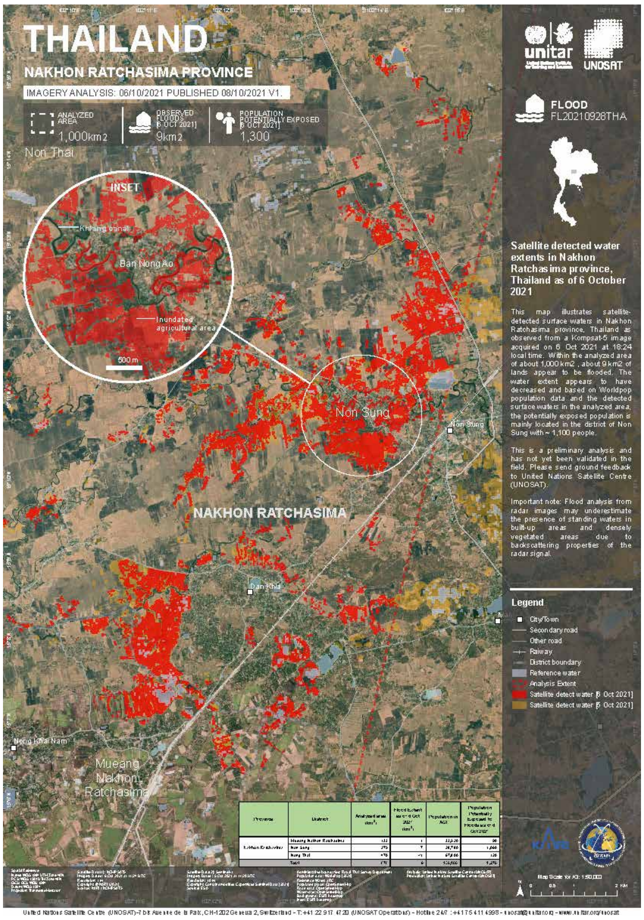
1. Global: Making data affordable through open-source data portals

In recent years, more regional and international initiatives have been developed to not only make data open and freely accessible, but also to help countries obtain affordable data which can be used for decision-making and actionable outcomes. Several examples, described in Chapter 2, highlighted some of these initiatives and how the data can be used to support countries in making actionable data-driven decisions. These include the FAO Agricultural Stress Index System (ASIS), which provides on-demand data and indicators on agriculturally-stressed areas at global, regional and country levels, and the ESCAP and UNOSAT Decision Support System tool which provides statistics and data on several indicators relating to disaster risk and climate, and other socioeconomic information for informed decision-making. Both of these examples provide data and statistics in different formats, which can be leveraged within countries.

Another key example that provides free, open-source data is the United Nations Satellite Centre (UNOSAT-UNITAR) emergency mapping service.[3] The UNOSAT emergency mapping service produces satellite-derived analysis to support disaster risk reduction and humanitarian operations. This data is made freely available through the UNOSAT website, and is commonly used by national space agencies and disaster management offices within countries.

Using the accessible and affordable UNOSAT data, agencies within Thailand were able to put this data into action during the 2021 flooding events (Figure 3.3). The UNOSAT rapid mapping team was activated with partners at GISTDA, and produced several comprehensive geospatial data analyses of the extensive flood situation. All of the products were made available to the end-users via online public dashboards and maps, which were updated daily to show evidence-based information. The information released was also frequently disseminated to local authorities and the population by the United Nations Thailand country office.

Figure 3.3: Example of UNOSAT satellite-derived data for flood analysis in Thailand, in 2021



Source: UNOSAT, 2022. Available at: https://unosat.org/products/ (accessed on 6 October 2022).

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

Thematic Area	SDGs
Disaster Risk Reduction and Resilience: Innovation, risk reduction, disaster assessment, emergency response, climate hazards **Social Development:** Vulnerable groups 	

Sentinel Asia[4] is another initiative that provides satellite-derived geospatial products to support disaster management within the Asia-Pacific region, which is led by the Asia-Pacific Regional Space Agency Forum (APRSAF). This initiative is an international collaboration among space agencies, disaster management agencies and international agencies which leverages geospatial applications to provide on-demand data for disaster preparedness and early warning, minimizing the number of victims and socioeconomic losses.

Actionable

1. Thailand: Actionable geospatial data for decision-making

Thailand is also applying advanced methods for social development initiatives, by undertaking extensive projects on mapping poverty and low-income housing areas. Geospatial data is being used at the national level to map out the density of the population living in poverty in all provinces, which aims to guide poverty reduction efforts. GISTDA is working with the National Housing Authority to create a database of low-income communities from aerial or satellite images using geo-informatics technology and tools. The National Housing Authority was developed to create a community database of low-income communities to assist in household planning in urban areas. This data helps governments in providing social welfare assistance, delivering services from the government, private sector and educational institutions, and deliverinng community facilities and utilities.

In addition, the National Economic and Social Development Council (NESDC) reports on the poverty and inequality situation in Thailand every year. Utilizing geospatial data, the NESDC report maps poverty information and statistics, such as poverty density across provinces in Thailand and contains information on the poverty ratio at the national, regional and provincial level.

Accessible, available and affordable geospatial data can be complemented with additional sectorial data, to be easily put into action for effective policymaking, particularly to determine the recipients of government funds. The Government of Thailand's use of digital technologies, together with advanced space technologies, demonstrates the importance of accessible, available and affordable data, and is a testament to its commitment to bringing prosperity and well-being to the nation.

Thematic Area	SDGs
Social Development: Poverty, vulnerable groups	

2. Malaysia: Actionable geospatial data for sustainable waste management

In Malaysia, government agencies are developing new innovative actionable approaches to using geospatial data for driving resilient and sustainable communities through improved waste management. The Solid Waste and Public Cleansing Management Corporation (SWCorp) has developed a technical solution that enables more cost-effective and environmentally friendly waste management practices.

This solution leverages advanced geospatial applications and data to create near real-time views of the entire waste management network. This will enable users and staff to access high levels of data and information easily and quickly for effective decision-making. Digitalizing the waste management system has increased efficiency across the network, resulting in the collection of more recycled items. This example demonstrates how data can be put into action to increase sustainable waste management efforts and contribute to making the city cleaner and greener.

Thematic Area	SDGs
Management of Natural Resources: Waste management, urban planning **Connectivity for the 2030 Agenda for Sustainable Development**: Transport systems	

Seven key success factors

The seven key success factors to leverage geospatial information for sustainable development emerged from the analysis of the 2020 edition of the compendium on Geospatial Practices for Sustainable Development in Asia and the Pacific (Figure 3.4) . These are also relevant in this context of implementing Phase I of the Plan of Action and provide specific areas where countries can further leverage geospatial data.

Figure 3.4: Seven key factors for success to leverage geospatial information for sustainable development

Source: *Geospatial Practices for Sustainable Development in Asia and the Pacific 2020: A Compendium* (United Nations publication, 2020).

Based on the analysis of the good practice examples from Chapter 2, the best practices highlighted throughout this chapter, and the seven factors illustrated in Figure 3.4, many countries within South-East Asia are making progress towards several key success factors. Namely:

- **Factor 2: Integrate geospatial data with other data sources**. Progress has been made towards this through SDG monitoring in Indonesia and geospatial and statistical data integration by ESCAP Statistics Division.

- **Factor 3: Use geospatial data for creating, implementing and monitoring policies**. Key examples of work toward Factor 3 include policy and decision-making in Thailand, which is being lead by geospatial data.

- **Factor 4: Incorporate geospatial information into national institutions and platforms**. Both Thailand and Indonesia are incorporating geospatial data into web-based platforms to monitor, for example, natural resources or manage disaster risk across multiple sectors.

- **Factor 6: Provide open data access**. Open data access is becoming widely available at both national and international scales through regional mechanisms, namely the UNOSAT emergency mapping and Sentinel Asia programme.

- **Factor 7: Collaborate on local to international levels**. This has been seen through several mechanisms, namely the ESCAP initiative; Pan-Asia Partnership for Geospatial Air Pollution Information (PAPGAI).

The examples touch lightly on the vast array of good practices, cross cutting several of the seven key success factors. While it can be seen that countries are making progress towards these, especially since the publication of the 2020 Compendium, more work is still needed to ensure all seven key success factors are utilized to their full potential. For example, geospatial practices under Factor 1: Invest in national experts and Factor 5: Ensure privacy, safety and ethics of data, are still lagging behind. Fully leveraging geospatial information for sustainable 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.

Conclusion

As countries within the Asia-Pacific region further develop and utilize geospatial data and applications, it is critical that this data be widely available, accessible, affordable and actionable. Such data can then adequately benefit people, inform practices, processes and policy, and to further aid policymaking should also be integrated, innovative and inter-disciplinary.

The best practice examples that have been described in this chapter demonstrate the effectiveness of available, accessible, affordable and actionable data at national, regional and international levels. These examples provide a baseline for countries to consider when developing their own programmes and initiatives and a space for them to recognize the work already undertaken by several member States.

Endnotes

1. United Nations, Department of Economic and Social Affairs (n.d.).
2. John Hopkins University of Medicine (2022).
3. United Nations Institute for Training and Research (UNITAR).
4. Sentinel Asia.

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Chapter 4

Trends and evolving subregional needs

The present chapter identifies the evolving needs of South-East Asian countries to accelerate the implementation of the Plan of Action on Space Applications for Sustainable Development in Asia and the Pacific (2018–2030) (Plan of Action). The aim is to shed light on the key gaps in implementation, and present subregional and country-specific priority needs. Through a greater understanding of needs, targeted actions can be taken to facilitate the achievement of the Plan of Action, particularly in Phase II.

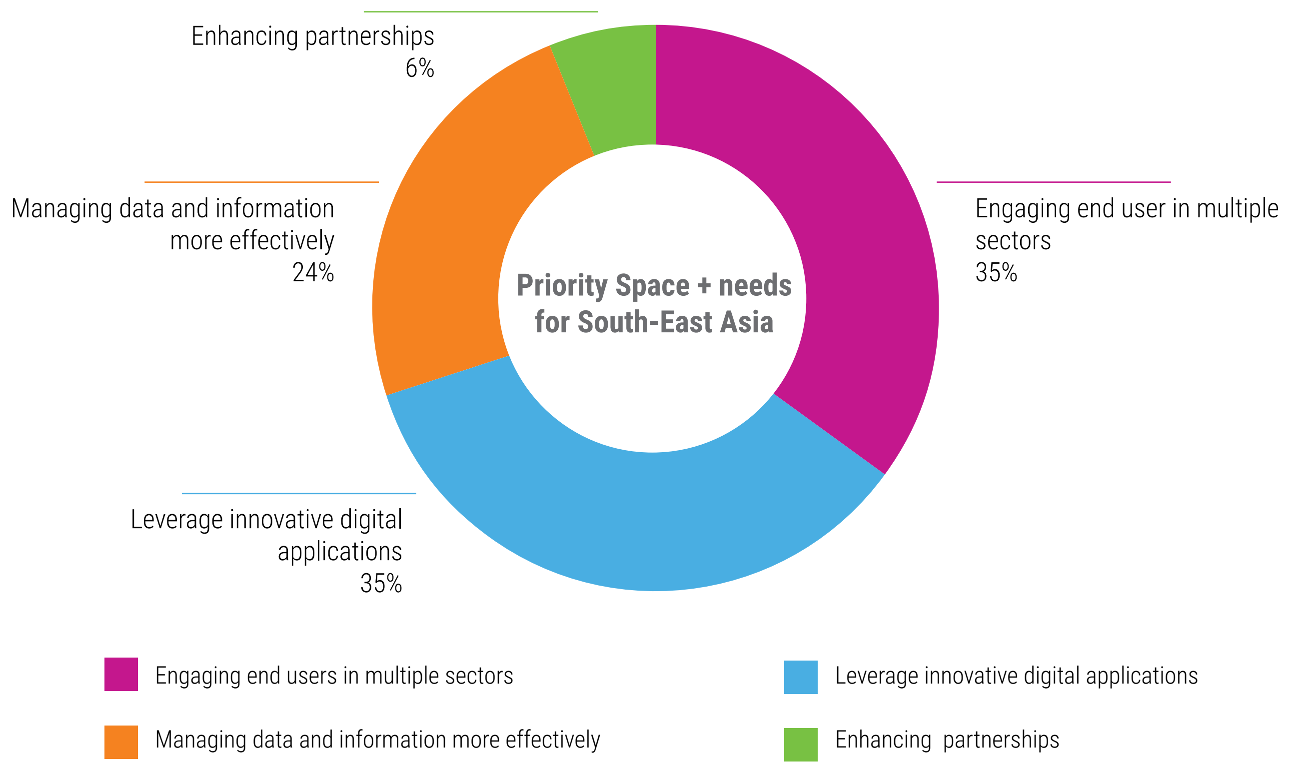
The findings of the chapter highlight the need to scale up action to address the current gaps. The demand for knowledge-sharing, technical support and expert training remains consistently high for member States to accelerate the Phase II implementation through the four elements of Space+. These findings point to the importance of continued action in the three modalities of implementation identified in the Plan of Action, namely (a) research and knowledge-sharing; (b) capacity-building and technical support; and (c) intergovernmental discussions and regional practices to ensure geospatial data and technologies are available, accessible, affordable and actionable in South-East Asia.

As seen in Chapter 2 and 3, South-East Asian countries have made progress in the achievement of the Plan of Action. Despite the advances made in enhancing the application of space applications for sustainable development, there is scope for countries to do more across the six thematic areas namely (a) disaster risk reduction and resilience, (b) management of natural resources, (c) connectivity for the 2030 Agenda for Sustainable Development, (d) social development, (e) energy, and (f) climate change. Gaps still exist, and to best address these gaps this chapter aims to understand the specific needs of countries organized along the four elements of Space+ (see Chapter 1).

This chapter presents the individual perspectives of ESCAP member States, which have been obtained through various processes and instruments. Responses to the secretariat's 2022 Questionnaire on Geospatial Practices for Sustainable Development in South-East Asia were analysed. In these responses, space agencies and relevant ministries, from countries in South-East Asia, highlighted their country's contributions to the 2030 Plan of Action, and identified the needs of their respective country to meet the requirements of Phase II of the Plan of Action for each of the six thematic areas. Through the use of the survey responses, country statements delivered at the annual sessions of the Intergovernmental Consultative Committee from 2020 to 2022, and the Evaluation of the Implementation of Phase I of the Plan of Action conducted by an independent evaluator, this chapter provides a summary of the most important needs in achieving Phase II of implementation based on ongoing dialogue with member States. These needs are grouped according to the elements of Space+, which is the guiding theme of Phase II implementation. Figure 4.1 presents the results of the analysis, summarizing the portion of total identified needs that fall under each Space+ category. Priorities are determined on the basis of the most frequently mentioned need by all South-East Asian member States.

Space+ priority needs identified across South-East Asia

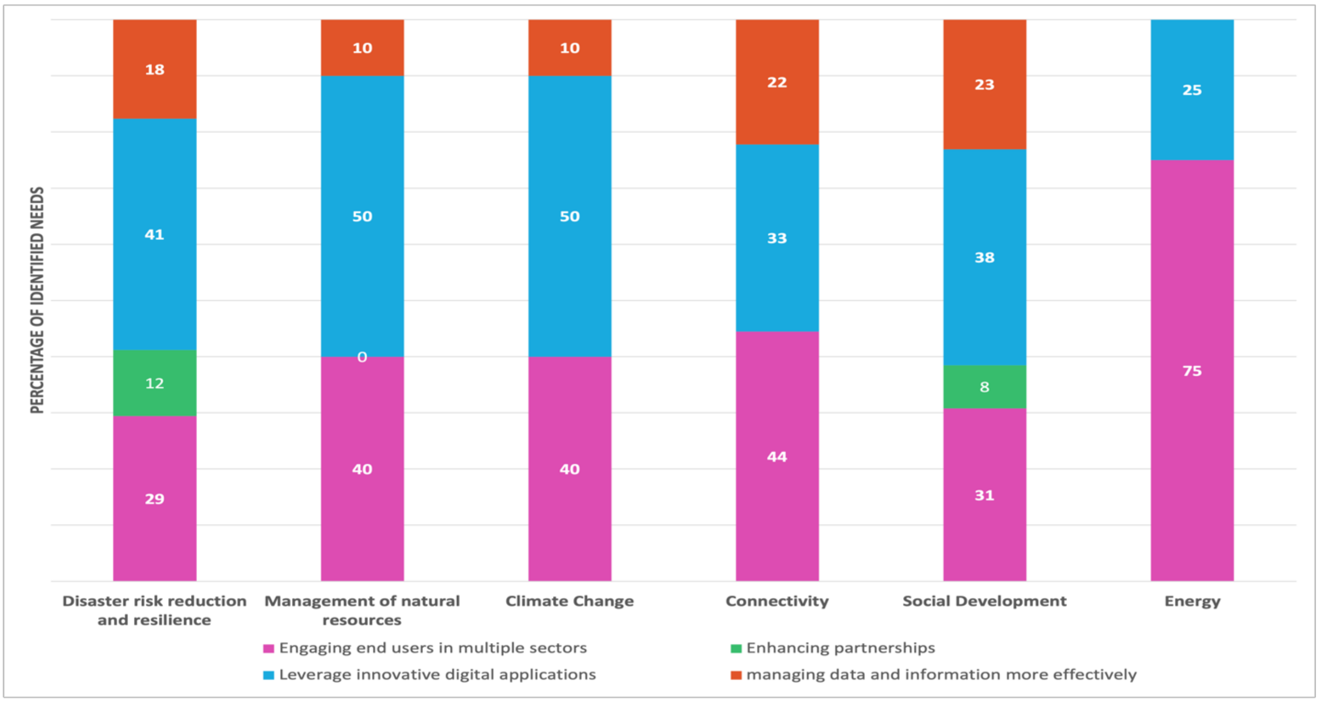
Figure 4.1: South-East Asia's identified Space+ priority needs



Source: ESCAP calculations based on frequency of mention by member States in their country statements at the annual session of the presentations from 2019 to 2022, and in their responses to the Questionnaire for Geospatial Practices for Sustainable Development in South-East Asia 2022 for each thematic area.

As shown in Figure 4.1, the most frequently stated need to successfully implement Phase II of the Plan of Action, for South-East Asian countries, is to leverage innovative digital technologies and engage end users in multiple sectors. South-East Asia needs to better leverage innovative digital and big technologies, such as satellite imagery, artificial intelligence (AI), geographic information systems (GIS) data, which in turn can be used for the collection, distribution and analysis of high-quality data. Another priority need for South-East Asia is to ensure that this data is actionable for end users, including the private sector, governments and target groups, such as youth and women, to increase its use for the achievement of the Sustainable Development Goals. While leveraging innovative digital applications and engaging end users is a commonly-stated need across the six thematic areas, as demonstrated in Figure 4.2, their applications are different within each of the specific areas.

Figure 4.2: Space + priorities for each thematic area in South-East Asia



Source: ESCAP calculations based on frequency of mention by member States in their country statements at the annual session of the presentations from 2019 to 2022, and in their responses to the Questionnaire for Geospatial Practices for Sustainable Development in South-East Asia 2022 for each thematic area.

Disaster risk reduction and resilience

South-East Asian countries also need access to innovative geospatial applications to monitor and forecast hazards. This is extremely important, as climate hazards are becoming more frequent throughout the region. Having access to on-demand geospatial data for disaster preparedness, response and mitigation is crucial for countries to make data-driven decisions. The technological needs of countries in the subregion are constantly evolving as technologies evolve and become better. Therefore, even countries currently at the forefront of good practices in space applications for disaster risk reduction and resilience have needs. For example, Singapore, a leader in the use of satellite data for monitoring of forest fires and haze and imagery in the subregion, has identified the need for more efficient and better ways of leveraging innovative space applications for monitoring. Additionally, geospatial data combined with, cloud computing and AI are needed to share and integrate satellite and other data sources to effectively monitor and map hazards and risks. Space applications and geospatial data-sharing, and integration technologies need to be leveraged hand-in-hand to ensure that geospatial applications are not only accessible but actionable to ensure disaster preparedness, mitigation, and response. As disasters are transboundary in nature, South-East Asian countries have also acknowledged the need for enhanced regional partnerships through expert geospatial training, joint research, and sharing of existing technologies to mitigate the effects of disasters in the subregion.

Management of natural resources

Space applications provide valuable data, information, and solutions to support sustainable natural resource management, which is imperative for sustainable development. It is therefore vital for South-East Asian countries to address their specific needs in this area. Countries in the subregion need to leverage innovative digital technologies to support geospatial data-sharing for effective environmental management and planning by end users. Singapore and Indonesia identified the need for increased remotely-sensed imagery, and ground validation data for verification and accuracy assessment to assist in improving the reliability and availability of geospatial data and applications for end users. In addition to the availability of such technologies, Thailand highlighted the need for more training on integrating new innovative technologies and concepts, such as big data, IOT, and cloud computing, with space applications to increase the ability of actors to share and process data. All countries also identified the need to increase the capacity of national human resources to better engage the government in the use of geospatial data and applications for better natural resource management.

Connectivity for the 2030 Agenda for Sustainable Development

Connectivity, requires greater levels of technological implementation and the ability of users from different countries and industries to leverage those technologies for the effective and efficient movement of goods, services, people, and information across borders.[1] For example, Thailand, highlighted the need for further use of geospatial applications and innovative technologies such as artificial intelligence, real-time supply chain visibility, predictive analytics platforms, and eco-logistics to enhance the capacity of their logistics systems to achieve the Sustainable Development Goals. Beyond making big data accessible for end users, human capacity-building and training in the various sectors is needed to engage end users and enable them to utilize geospatial data to help enhance connectivity in South-East Asia.

Social development

Ensuring that no one is left behind, particularly in terms of increase in income, availability of jobs, and access to basic services and opportunities, is at the forefront of social development planning, in South-East Asia.[2] Thus, having available, accessible, affordable and actionable geospatial data to map poverty and vulnerable groups, and to identify risks is critical. To this end, South-East Asian countries have pointed to the need for greater budgetary availability and training for countries to increase their capacity to leverage digital innovations and geospatial data for social development. In addition to greater affordability and actionability of innovative technologies, Thailand has identified the need for greater data-sharing between regional partners.

Energy

Energy plays a significant role in sustainable development and South-East Asian countries recognize the need for access to affordable, reliable, sustainable and modern energy for all.[3] Space applications and geospatial data are constantly evolving, particularly in the availability and use of more sustainable and inclusive energy. Therefore, South-East Asian countries have highlighted the need for greater cooperation amongst regional partners, as well as with end users in different sectors to enhance the research and further development of technologies and geospatial applications to improve the identification of opportunities for, implementation of, and improvement of sustainable energy solutions.

Climate change

Climate change has drastically and adversely affected South-East Asian countries. In order to respond effectively to the urgent threat of climate change, access to digital technologies that can help monitor and track climate change drivers, such as greenhouse gases is critically needed. Singapore has identified the need for concepts, such as Internet of Things (IOT) and big data, to help monitor the effect of climate change drivers such as greenhouse gas emissions, and how they might affect factors such as sea level rise. Beyond access and availability of technology to measure the effect of greenhouse gas emissions, Singapore has also highlighted the need to enhance partnerships in researching the effects of sea level rises, and the possible implementation of space applications to assist in climate change and sea level rise mitigation. Thailand has also identified similar needs, noting the need to leverage sensor data to track the causes of greenhouse gas emissions, and find methods to measure carbon sequestration. With the increase of innovative digital technologies, new satellites are being launched that contain sensors that are able to more accurately track and monitor greenhouse gases. In addition to leveraging new technologies, South-East Asian countries have identified the need for greater capacity development and human resource training within the field of geospatial applications and data to assist with climate change. Climate change has significant impacts on extreme weather events, increasing the frequency and the magnitude of droughts, floods, and storms. It also has significant effects on social development and human health, thereby making it pivotal for South-East Asian countries to meet their digital needs to minimize the impacts of climate change.[4]

Summary

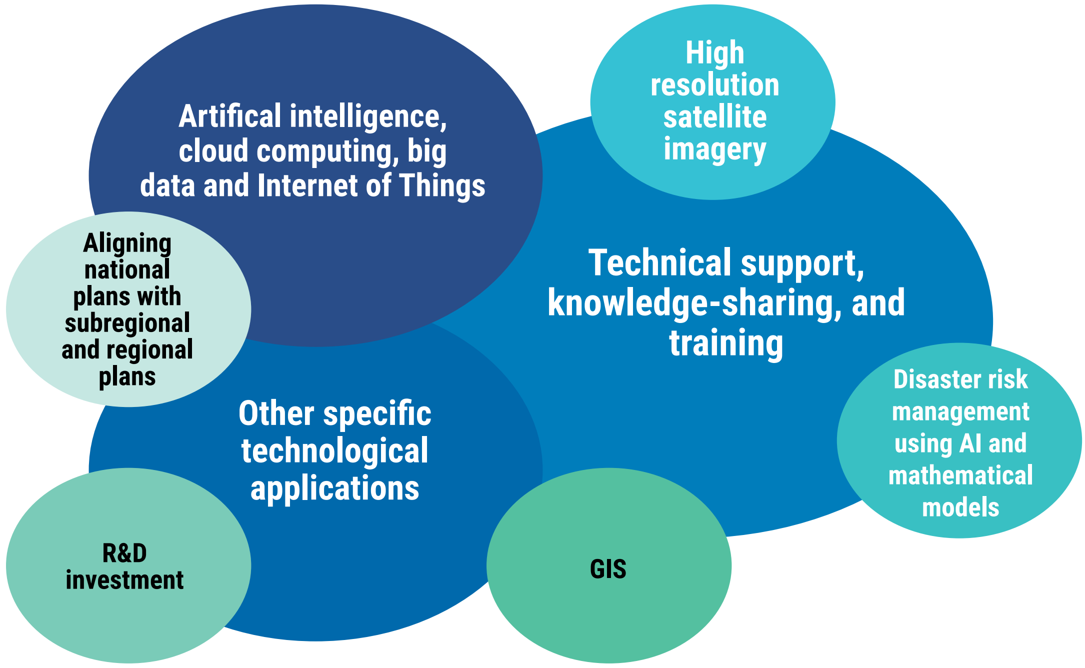
All four of the components of Space+ need to be enhanced across all thematic areas for the implementation of Phase II of the Plan of Action. While all thematic areas share the need to better leverage digital technologies and engage end users, each area has distinctive needs that need to be met. Partnerships between sectors in each thematic area can help South-East Asian countries meet the Plan of Action by sharing best practices, technology, and applications, and increasing the accessibility to greater cross-sectoral data.

Space+ priority needs identified across South-East Asia

1. Leveraging innovative digital technologies

Digital innovations have been transforming the way space-based data is managed, stored, and integrated with data from the ground and other diverse sources, including mobile smart phones, IOT devices, and drones. From the perspective of promoting applications for societal benefit, these innovative digital applications have transformed how the resulting information and analytics could be delivered to and utilized by end-users, as shown in the examples in previous chapters. Figure 4.3 identifies the key priorities for South-East Asian countries to best leverage innovative digital technologies for space applications. The size of the bubbles reflects their respective importance.

Figure 4.3: Top priorities for South-East Asian countries to best leverage innovative digital technologies



Note: The size of the bubbles indicates the relative importance of each need based on the frequency of mention by member States in their responses to the Questionnaire for Geospatial Practices for Sustainable Development in South-East Asia 2022, and in their ICC country statements of the 2020, 2021 and 2022 sessions.

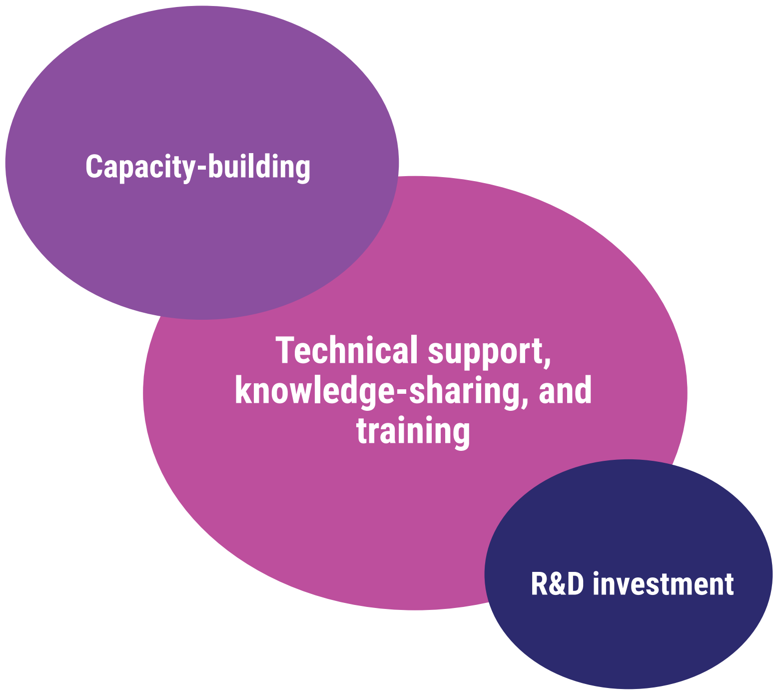
ESCAP analysis shows that countries need access to a diverse range of innovative digital technologies and the knowledge on their specific applications to completely leverage data-driven decisions for sustainable development. Geospatial information integration with artificial intelligence, cloud computing, big data and IOT were overwhelmingly the most needed technologies identified by member States, while other forms of technology, such as the need for more high-resolution satellite imagery were also mentioned. While ensuring that member States have access to existing technology is of great importance, often the most prominent barrier faced by countries is not the access to digital technologies but rather the capacity and knowledge to develop effective, meaningful and useful applications and products utilising such technologies. ESCAP's analysis of the needs of its member States demonstrates that the best way to support countries is through knowledge-sharing by means of technical support and expert workshops. Through knowledge-sharing, countries can fill their own gaps while helping other regional partners, as expertise differs across countries.

In response to the Questionnaire for Geospatial Practices for Sustainable Development in South-East Asia 2022, Singapore noted that it would benefit from knowledge-sharing on the application of IOT and big data in exploring the linkages and effects of greenhouse gas emissions on sea levels. Therefore, training by regional experts, and knowledge-sharing on the application of technologies and concepts, such as big data, IOT, cloud computing and unmanned aerial vehicles (UAV) in the context of geospatial applications for sustainable development has been identified as a top priority in Phase II of implementation of the Plan of Action, and for the achievement of the Sustainable Development Goals.

2. Engaging end users in multiple sectors

South-East Asian countries recognize the need to engage multiple sectors for knowledge creation and applied applications, and have identified this as one of their key needs in the Phase II implementation. Figure 4.4 provides an overview of three key areas of focus within this priority. Countries within South-East Asia will all benefit from increased technical support, knowledge sharing and training, at both the national, regional and international scale. In all thematic areas, emphasis is on training through multi-disciplinary expertise to develop and use integrated geospatial systems, data and analysis. Capacity-development, particularly that of national human resources, has also been identified as critical. These opportunities give space for countries to develop and strengthen their usage of space applications which in turn will promote better decision-making and data-driven actions. New models of engagement within space applications of youth, women, and the private sector under each thematic area is needed to foster inclusivity and create jobs and opportunities for all.

Figure 4.4: **Top priorities for South-East Asian countries to engage end users in multiple sectors**

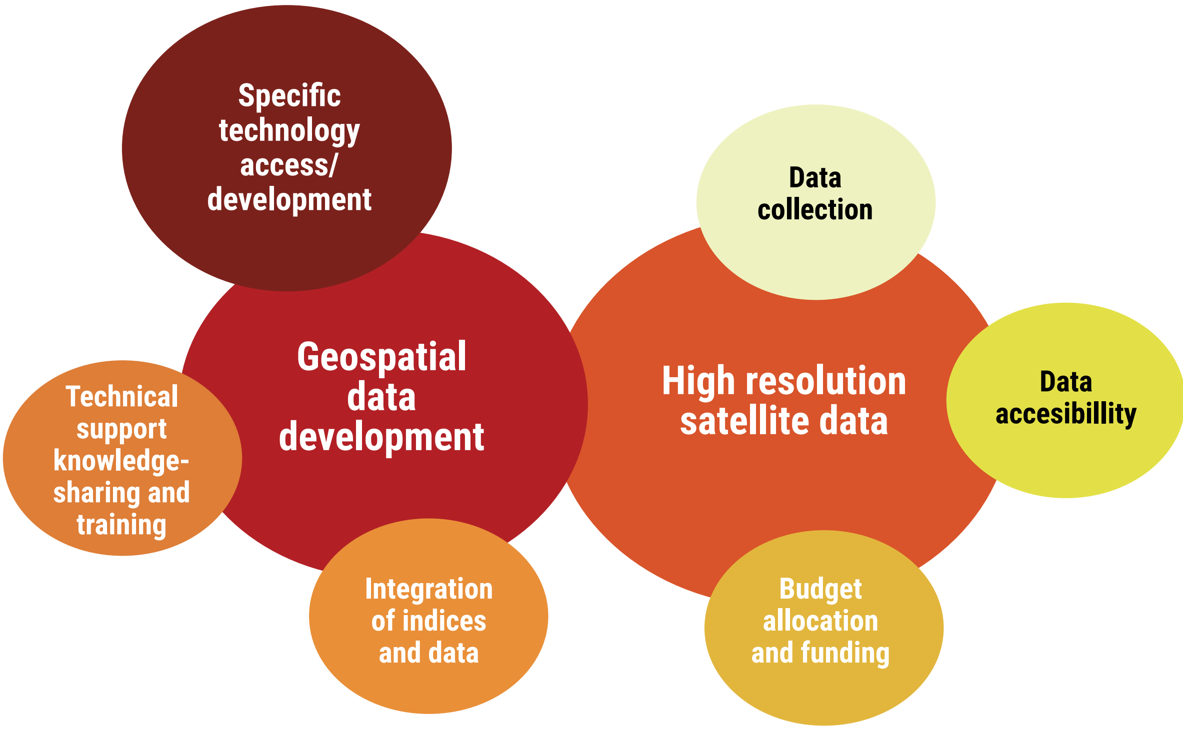


Note: The size of the bubbles indicates the relative importance of each need based on the frequency of mention by member States in their responses to the Questionnaire for Geospatial Practices for Sustainable Development in South-East Asia 2022, and in their ICC country statements of the 2020, 2021 and 2022 sessions.

3. Managing data and information more effectively

Geospatial data and information are needed to contribute to all facets of sustainable development, and is critical to the knowledge economy. Through geospatial data, countries can develop a blueprint of what happens where and when, and help decision-makers to best address challenges. When managed effectively, end users, including governments, and the private-sector, can utilize this data to contribute to economic growth, sustainable social development, environmental sustainability, and national prosperity.[5] As demonstrated in Chapter 3, geospatial data needs to be accessible, available, actionable, and affordable for countries to maximize its utility gain. South-East Asian countries have highlighted priority needs to ensure that geospatial data is benefiting people, informing practices, processes, and policies. Figure 4.5 presents the key needs as identified by member States, with the availability of geospatial data and high-resolution satellite data highlighted as key areas of importance. It is critical to make this type of data more readily available, either through data-sharing practices, budget allocation and funding which make this data more affordable for countries to obtain. However, the technical limitations that come with obtaining this data need to be considered. For example, countries may not have the adequate computing power or knowledge to analyze and use this data to its full potential. This is where specific technology access, development and support plays a role to bridge these gaps.

Figure 4.5: Top priorities for South-East Asian countries to manage data and information more effectively



Note: The size of the bubbles indicates the relative importance of each need based on the frequency of mention by member States in their responses to the Questionnaire for Geospatial Practices for Sustainable Development in South-East Asia 2022, and in their ICC country statements of the 2020, 2021 and 2022 sessions.

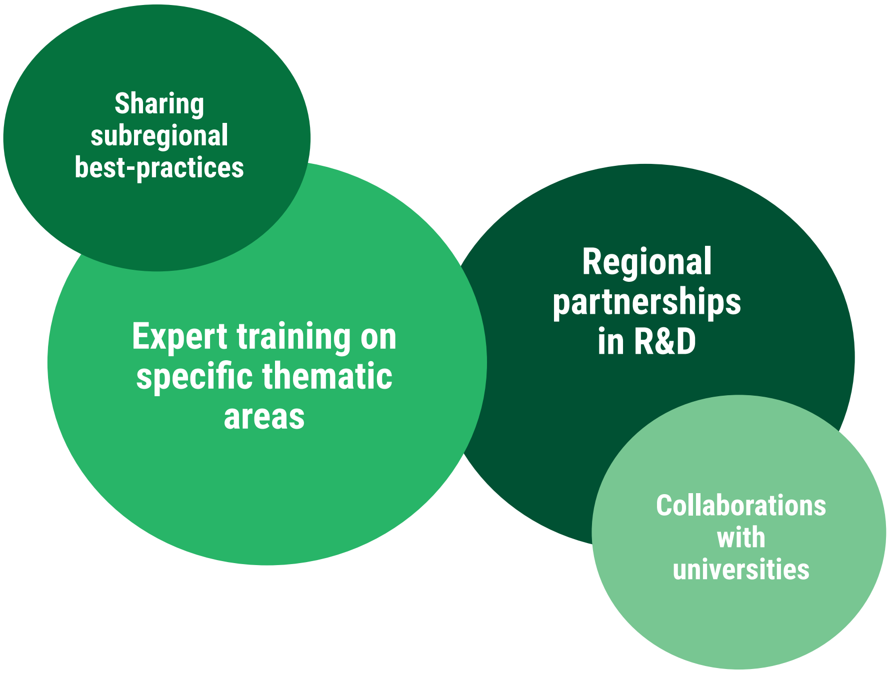
Without affordable data availability and accessibility, efforts to make data actionable through better management is wasted. South-East Asian countries have recognized the utmost importance of data availability, and identified greater access to geospatial data as a top priority. All data, especially the integration of geospatial data with cross-sectorial data, is critical for planning and development, therefore the availability of accessing this is essential for countries to push forward and make gains toward sustainable development. However, as countries develop their digital technologies at different rates, gaps still persist. Countries need to leverage innovative technologies to collect more data, and this data needs to be accessible and available between countries and regions. There is also a strong recognition of the need to accelerate use of new and diversified sources of data, such as, multitemporal satellite data with advanced tools (e.g., artificial intelligence analytics), the Internet of Things, drones, and crowdsourcing.

At the national level, member States have identified the priority need to develop and foster greater capacity for institutional collaboration through technical support and knowledge-sharing, interoperability and integration across the various national government data information systems, platforms and policy processes. Various institutional arrangements are considered for strengthening the management of geospatial information. Effective management of geospatial information makes it possible to address many development challenges, and to bridge the geospatial digital divide in the subregion. Thus, significantly expanding the availability of high-quality, timely and reliable data disaggregated by geographic location and several other metrics, across more countries, and building the technical skills to exploit the use of such data is critical for the region in order to achieve Phase II of the Plan of Action and the 2030 Agenda. The integration of location-based information with other data relevant to people's lives and livelihoods is crucial for providing better and more useful information for sustainable development. Such data integration results in better insights, which lead to shared understanding, and which in turn will enable us to better achieve local, national and international goals and make informed decisions.

4. Strengthening implementation through enhanced partnerships with national, regional and global stakeholders

Given the breadth of thematic and sectoral areas where geospatial information and space applications can add value, there is a need for enhanced partnerships with national, regional, and global stakeholders. Many of the problems that space applications aim to solve are transnational and therefore require collective efforts. South-East Asian countries appreciate the importance of greater partnerships and have identified some key areas of greater cooperation needed for the implementation of Phase II of the Plan of Action. Figure 4.6 presents these priority areas.

Figure 4.6: Top priority needs to strengthen partnerships in South-East Asian countries



Note: The size of the bubbles indicates the relative importance of each need based on the frequency of mention by member States in their responses to the Questionnaire for Geospatial Practices for Sustainable Development in South-East Asia 2022, and in their ICC country statements of the 2020, 2021 and 2022 sessions.

Enhanced partnerships are needed primarily through knowledge-sharing and creation between different sectors and countries in South-East Asia. Through expert training on how geospatial data and space applications can be leveraged across each of the thematic areas, countries can ensure that geospatial data is accessible to all and is inclusive. Collaborations in the research and development of new technologies through regional partnerships, and engagement with universities are needed to increase the availability of new technology and information making these innovations actionable. Such partnerships are the backbone of ensuring that South-East Asian countries meet their needs in achieving the Plan of Action in every stage of its implementation, be it through increasing availability, enhancing accessibility, improving affordability or ensuring actionability. Through such collaborations, countries and sectors can improve and learn from one another.

Conclusion

Making sure that geospatial data is available by leveraging digital technologies, and ensuring that this data is available, accessible, affordable, and actionable by engaging end-users in multiple sectors are the most prominent needs of South-East Asian countries in meeting the implementation of Phase II of the Plan of Action.

The four components of Space + have been put forth as ways to transcend traditional space applications to successfully implement Phase II of the Plan of Action (See Chapter 1).[6] These four components are interlinked, and can provide an efficient pathway to the achievement of Phase II, however this is only successful when countries leverage their all four Space+ elements simultaneously. New technologies, made available through greater innovation, paired with affordable access to these technologies through greater partnerships and policymaking need to be leveraged to make sure that geospatial data is available, accessible, affordable and actionable. The widespread availability of technologies, such as satellite imagery, paired with cloud-based processing tools, and access to other technologies, such as the Internet of Things (IOT) and unmanned aerial vehicles (UAV), enables countries to obtain and use geospatial data for informed decision-making.[7] However, to ensure that geospatial data is actionable, there also needs to be coordination between producers and users of geospatial information. Through partnerships, data-sharing and integration technologies, data can be made affordable and accessible to end users.

Endnotes

1. United Nations Economic and Social Commission for Asia-Pacific (ESCAP) (2020).
2. Ibid.
3. Ibid.
4. Ibid.
5. United Nations Economic and Social Commission for Asia-Pacific (ESCAP) (forthcoming a).
6. United Nations Economic and Social Commission for Asia-Pacific (ESCAP) (forthcoming b).
7. United Nations Economic and Social Commission for Asia-Pacific (ESCAP) (forthcoming a).

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United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) (2020). *Geospatial Practices for Sustainable Development in Asia and the Pacific: A Compendium*. United Nations publication.

_________ (forthcoming a). Integration of Space, ICT & Geospatial Applications in SPACE+ for our Earth and Future.

_________ (forthcoming b). Scaling up space applications to advance sustainable development in Asia and the Pacific through Space+ for our Earth and future.

Chapter 5

Policy recommendations for accelerating the implementation of the Plan of Action in South-East Asia

Introduction

Chapter 2 and 3 demonstrated the wide range of space applications that are being used in South-East Asia to support sustainable development. The chapters showed that the use of space and geospatial applications have increased, diversified, and gained increasing traction since ESCAP began tracking them in the context of monitoring the implementation of the Plan of Action on Space Applications for Sustainable Development in Asia and the Pacific (2018–2030). Geospatial information has played a critical role in providing information to manage and respond to the various challenges posed by the COVID-19 pandemic. This has been vividly demonstrated, in the past two years, as epidemiological information, and information pertaining to the development of response and policies to manage the socioeconomic impacts of the pandemic, was efficiently and effectively provided.

The implementation of the Plan of Action on Space Applications for Sustainable Development in Asia and the Pacific (2018–2030) (Plan of Action) offers a critical opportunity to address the uneven progress in space applications across countries with a focus on addressing the capacity needs and gaps that were described in Chapter 4. National actions are most critical in addressing these needs and gaps but upgrading and scaling up regional cooperation is indispensable to accelerate the speed with which countries could benefit from space applications. The Fourth Ministerial Conference on Space Applications for Sustainable Development in Asia and the Pacific will be jointly organized by the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), and the Government of Indonesia on Wednesday, 26 October 2022 in Jakarta, Indonesia to sustain and reinforce regional cooperation to expand the access to space and geospatial information for sustainable development in the region.

In this vein, discussions at ESCAP, over the past three years and in the context of the Intergovernmental Consultative Committee (ICC) on RESAP, have converged around four foundational elements which are encapsulated in the theme *Space+ for our Earth and future*. Its main thrust is to enable governments to transcend traditional space applications by promoting innovative applications of space and geospatial information in tandem with digital innovation, web-based geospatial technologies, research, knowledge-sharing and capacity-building.

The policy recommendations for South-East Asian countries in this chapter is organized around the four elements of Space+, namely (a) leveraging innovative digital applications; (b) engaging end users, including the private sector and youth; (c) managing data and information more effectively; and (d) enhancing partnerships with national, regional and global stakeholders. A fifth recommendation is to strengthen the complementarity between ESCAP and ASEAN efforts (Figure 5.1).

Figure 5.1: Policy recommendations

RECOMMENDATION 1

Leverage innovative digital applications

Emerging technologies have the potential to help countries to make geospatial data accessible, available, actionable, and affordable. Such technologies offer unparalleled access to how information can be accessed, processed, stored and applied.

RECOMMENDATION 2

Engage end users, including the private sector and youth

Space agencies in the region have and need to continue taking comprehensive steps to reach out to sectoral user agencies to better understand their geospatial information and application requirements.

RECOMMENDATION 3

Manage data and information more effectively

To facilitate widespread data availability and usage, national geospatial databases should be hosted on web-based platforms, bring together countries and making data more accessible and available.

RECOMMENDATION 4

Enhance partnerships with national, regional and global stakeholders

The Plan of Action strengthens collaborative actions between global stakeholders and increases harmonisation of relevant initiatives and mechanisms.

RECOMMENDATION 5

Enhance the complementarity between the implementation of the Plan of Action and the work of relevant ASEAN bodies

These partnerships provide opportunities for supporting space applications for sustainable development.

Recommendation 1: Leverage innovative digital applications

The emerging technologies and resulting applications brought about by the fourth industrial revolution and their applications (as described in Chapter 1) offers transformative potential in terms of helping countries make geospatial data more accessible, available, actionable, and affordable. From the perspective of users, such technologies and applications offer unparalleled access to knowledge, and transform the way information can be accessed, processed, stored and applied.

When compared with previous industrial revolutions, the fourth industrial revolution (see Chapter 1) is evolving at an exponential rather than a linear pace.[1] Therefore, countries need to rapidly build their capacity to leverage innovative digital applications to ensure that no country is left behind. Chapter 2 highlighted some of the innovative digital geospatial applications that are already operational. At the national level, sectoral policies and/or dedicated space applications programme need to be upgraded to ensure that this is properly resourced. Policy actions, at the national level, will be needed to create the conditions for removing barriers to accessing space data and applications through policy frameworks. They could also incentivize private commercial entities to offer access to satellite data and related products for sustainable development.

Regional cooperation could reinforce national efforts by providing support to countries to acquire skills to use specific technologies. Regional mechanisms could be also tapped to build the capacity of countries to customize and/or replicate successful practices, such as those describe in Chapters 2 and 3, where appropriate. In addition, regional mechanisms within ESCAP could be also used to foster the development of standards and guidelines for integrating geospatial information with other sources of data to support relevant activities. Furthermore, good practices can also be promoted in terms of sharing of geospatial information, satellite data, and space applications among those member States working with existing intergovernmental mechanisms, and international and technical organizations. ESCAP platforms for intergovernmental discussions and regional practices can be used to encourage countries in the region to share knowledge, showcase good practices and demonstrate successful innovations for other member nations to benefit from. Such actions will help all countries to leapfrog and facilitate the uptake of applications.

To demonstrate the benefits of innovative digital applications in practice, the Government of Indonesia, as the host of the Fourth Ministerial Conference, is launching an initiative to enhance resilience to floods and wildfires, in Asia and the Pacific, using geospatial information and digital technologies, such as cognitive models, big data, and cloud computing (See Box 5.1).

Recommendation 2: Engage end users, including the private sector and youth

In the past, engagement with end users received much less attention than the production of space-based and geospatial information itself. But the paradigm has been changing fast. Some space agencies, in the region, have taken comprehensive steps to reach out to sectoral user agencies to better understand their geospatial information and application requirements and address them with appropriate solutions. As Chapter 2 shown, the Philippines and Thailand have taken concrete steps towards mapping users and their needs. Other countries have engaged users from the outset to respond to specific needs of applications, in terms of socioeconomic/poverty profiling, fisheries management, and crop suitability analysis, to mention a few. Thailand is developing an open geospatial platform called "Sphere" to drive space application development in a manner that leverages advanced innovative space-based technology and multi-sectoral collaborations (Figure 5.2).[2]

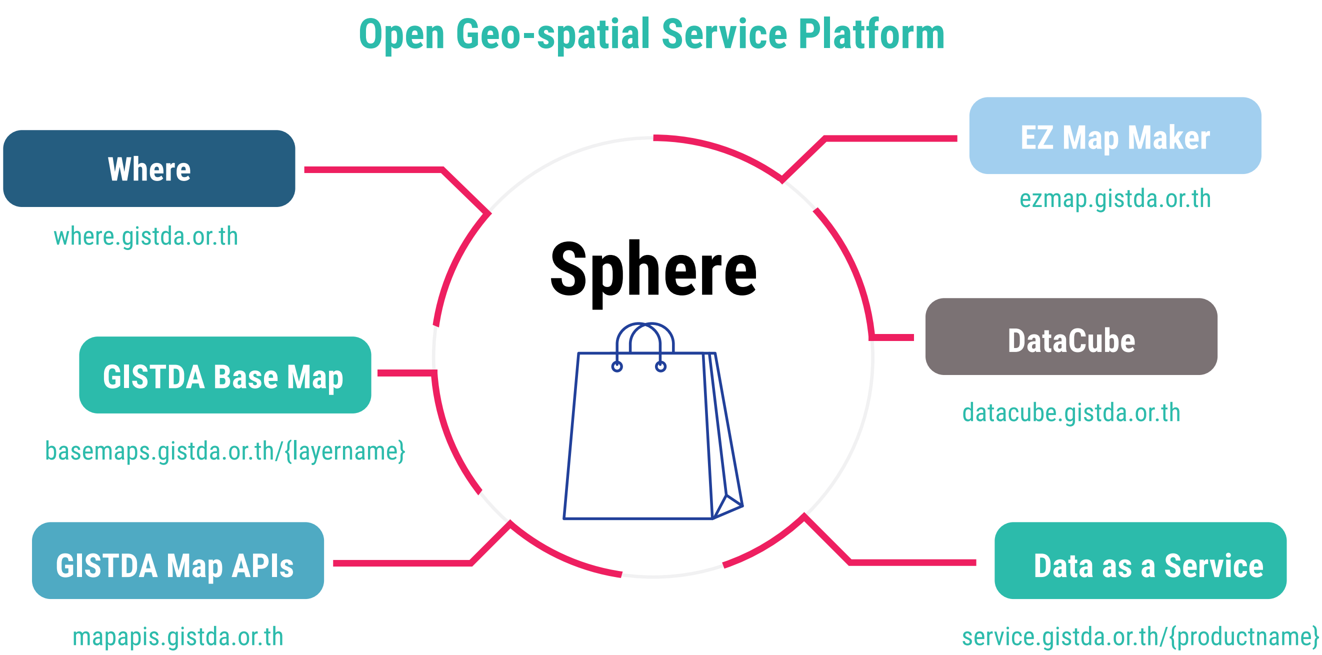
Box 5.1: Enhancing resilience to floods and wildfires in Asia and the Pacific using geospatial information and digital technologies

Satellite data is widely utilized to map and quantify the impact of flooding and wildfire events. However, the majority of mapping is performed during or in the immediate aftermath of these disasters. This nowcasting of floods and wildfires has led to information and capacity gaps where forecasting centres, in flood and wildfire-prone countries, lack the ability to generate historical trends, hotspots, and risk maps related to these disasters,[a] which are critical to understanding the related socioeconomic impacts and risks. Furthermore, the existing inundation, hotspot and risk maps in these countries are not up to date. Their low spatial resolution limits their usefulness to policymakers to gauge the evolving impacts of rapid urban development or climate change.[b]

To address such information and capacity gaps, Indonesia will kick-start a regional cooperation initiative to produce historical trends, hotspots and risk maps for floods and wildfires using open-source models. The models will improve current flood and wildfire risk monitoring and management systems and reduce human and economic losses, in Asia and the Pacific, caused due to these disasters. Data and information gaps will be bridged using digital technologies, such as cognitive models, big Earth data, and cloud computing. The models will also improve the spatial and temporal coverage of national and regional flood and wildfire early warning and risk management systems and build the capacity of flood forecasting centres in the region.

a. Duminda Perera, and others, "Challenges and Technical Advances in Flood Early Warning Systems (FEWSs)", in *Flood Impact Mitigation and Resilience Enhancement*, Guangwei Huang ed. (London, IntechOpen, 2020). Available at DOI: 10.5772/intechopen.93069
b. Institute of Catastrophic Loss Reduction, "Focus on Flood mapping in Canada", 2019. Available at https://www.iclr.org/wp-content/uploads/2019/09/ICLR_Flood-mapping_2019.pdf

Figure 5.2: **Schematic of Thailand's open geospatial service platform**



Source: Tatiya Chuentragun, "Summary of the progress in implementation of the Regional Space Plan of Action Phase I (2018-2022)", 2022. Available at https://www.unescap.org/sites/default/d8files/event-documents/ Thailand%20.pdf.

Multi-country projects could be implemented to demonstrate how geospatial information can be applied within a specific decision-making context. A key feature of such demonstration projects is the engagement of space agencies with a specific agency or group of user agencies to co-create the type of information needed, test the application, and receive feedback on the relevance of the parameters provided, and on their presentation and delivery. For example, and as featured in Chapter 2, an ongoing project in Indonesia and Thailand, with support from China, is an example of this. The project involves the close engagement between the space agencies and city authorities to build institutional capacity to use integrated spatio-temporal data in local SDG monitoring and decision-making is the main feature of the project.[3]

Space+ promotes and enhances knowledge among young scientists as well as young users, in general. It promotes the sharing of best practices in promoting women's participation in science and technology education. The emphasis is on training a workforce with multidisciplinary expertise to develop and use integrated geospatial systems and analysis across the region, in line with the modalities contained in the Plan of Action. Capacity development that provides employment and educational opportunities, through scholarships, exchange programmes and remotely through participation in massive open online courses, would be crucial (See Box 5.3 for examples).

As governments accelerate their use of geospatial technologies, long-term sustainability will depend on policies that support the inclusion of technologies in national curricula with special measures to increase the participation of young women. Opportunities to connect internationally with peers are also important. In addition to formal learning and training programmes, hackathons and innovation challenges present further opportunities to engage the youth.

The ASEAN University Network could be tapped to strengthen the link across academic research, operations and policy development. Deliberate efforts could be made to systematically link the research of the ASEAN University Network with the research agenda of universities with unmet gaps and needs in operations, as described in Chapter 4.

Models of productively engaging the private sector, to deliver goods and services for societal benefit, are emerging. The Government of the Philippines recently granted a license to a private company to provide affordable broadband Internet services using low-orbit satellites in remote rural areas. This is expected to bring a range of benefits, including an increase in micro, small and medium-sized enterprises. Through its Earth Analytics Science and Innovation platform, the Commonwealth Scientific and Industrial Research Organisation (CSIRO) of Australia has initiated schemes to remove barriers for small and medium-sized enterprises to access large-scale storage and computing infrastructure and data acquisition.[4] Similarly, in India many new start-ups and industries have taken up a whole range of activities in the space sector following the opportunities opened up by the recent space policy reforms at the national level.

These initiatives are in their early stages. ESCAP platforms and knowledge products could be used to share lessons learned regarding new models of engagement with the private sector on space applications. These can include good practices for fostering entrepreneurial activities to transform space and other data into social and economic services in a way that also creates jobs and opportunities for all.

Box 5.2: Examples of youth engagement

The first regional youth forum on the innovative use of geospatial information for resilient and sustainable development was organized by ESCAP, in collaboration with the Geo-Informatics and Space Technology Development Agency of Thailand, the ASEAN Research and Training Centre for Space Technology and Applications, Multi-GNSS Asia, the United Nations Satellite Centre, the Centre for Space Science and Technology Education in Asia and the Pacific, and the Asian Institute of Technology and was held in Phuket, Thailand, on 10 and 11 March 2022.

Multi GNSS Asia and the Geo-Informatics and Space Technology Development Agency of Thailand have co-organized a rapid prototype development challenge in the past to explore youth-led innovations on solutions for disaster mitigation: tsunami and flooding. Similarly, ASEAN Geospatial, a cooperative network of ASEAN geospatial agencies, as well as companies and professional networks partnered with the National Mapping and Resource Information Authority of the Philippines for the ASEAN Geospatial Challenge 2021: Youth Edition, with the goal of cultivating good relationships and encouraging collaboration among youth in ASEAN countries, improving geospatial competencies and increasing interest in the geospatial field. Winning projects received support from the sponsor agencies for further development and implementation. These kinds of opportunities will be crucial in building the next generation of experts with strong interest and aptitude in the various fields of space applications.

The Philippine Space Agency (PhilSA) has been running a scholarship program to support students interested in pursuing postgraduate studies in space science, technology and their applications. Indonesia will organize a Youth Forum on Space Applications on Sustainable Development as part of the regional initiatives that its Government is rolling out as a host of the Fourth Ministerial Conference.

Box 5.3: Virtual constellation of satellite for disaster risk management

Satellite imagery has been successfully used by the spacefaring nations in Asia and the Pacific to continuously monitor areas with high disaster risk and frequency of disasters to generate enhanced risk analytics like monitoring, forecasting and disaster early warning, surveillance, and impact assessment.[a] This frequent and targeted monitoring using satellite imagery is transforming disaster risk reduction and thus addresses some of the deep uncertainties in managing systemic risk.[b, c]

However, the high disaster risk and low-capacity countries in Asia and the Pacific remain highly vulnerable to disaster risks mainly due to their inability to continuously monitor and maintain vast national territories susceptible to high disaster risks. Access to satellite imagery could help improve their ability to generate the necessary risk analytics for disaster risk management.[d]

To address this data gap, the Indonesian Government, through its National Research and Innovation Agency (BRIN), is leading the initiation of the Virtual Constellation for Disaster Risk Management (VCDRM). For the Asia-Pacific region, the VCDRM will serve as a bridging mechanism to enable the flow of critical satellite imagery from spacefaring countries to the high disaster risk and low-capacity countries which lack the resources to procure the satellite imagery for continuous monitoring of high-risk areas. Under the guidance of RESAP member States, the VCDRM will define the satellite imagery-sharing mechanism in the region and establish a database to enable matchmaking of the demands and supplies of satellite imagery. The VCDRM concept follows the UN Secretary Generals' Data Strategy by ensuring greater data accessibility and sharing internally and externally.[e] The VCDRM also contributes to implementing the Plan of Action and Regional Roadmap by enabling research, knowledge-sharing and capacity-building and technical support.[f, g]

It also supports the Sendai Framework for Disaster Risk Reduction 2015-2030 by promoting the collection, analysis, management and use of relevant data and practical information, and ensures its dissemination, taking into account the needs of different categories of users, as appropriate.[h]

Initial consultations with ESCAP members converged around three objectives of the VCDRM. The first is that it should serve as a satellite imagery-sharing mechanism that (a) enables spacefaring countries to understand the regional needs and contribute to VCDRM by allocating a percentage of their satellite(s)'s operational time, and (b) enables the high disaster risk and low-capacity countries to access and consume the relevant satellite imagery available via VCDRM. Second, it should improve the capacity of local governments and disaster management-related agencies in the higher disaster risk and low-capacity countries to conduct comprehensive, coordinated, and sustained observations of the selected areas to address pre-disaster data gaps and improve disaster monitoring, map trends, increase disaster understanding and improve risk mapping capacity. And finally, that it should provide valuable inputs to the spacefaring nations to design and develop future satellites and sensors which address the national and regional data needs.

The twenty-sixth session of the Intergovernmental Consultative Committee decided to convene an ad-hoc scientific advisory group with experts from China, India, Japan, the Philippines, Sri Lanka, Thailand and other members who may wish to join the proposed regional initiatives to assist Indonesia in further developing the technical details of the virtual constellation of satellites for disaster risk management which includes, among others, satellite image-sharing mechanism, regional knowledge-sharing and capacity-building, and database solutions.

a. Jidong Wu, "Leveraging space-based satellite technologies for emergencies and disasters in China", Global Facility for Disaster Reduction and Recovery, World Bank, August 2020. Available at https://www.gfdrr.org/en/feature-story/leveraging-space-based-satellite-technologies-emergencies-and-disasters-china
b. Kazuya Kaku, "Satellite remote sensing for disaster management and support: A holistic and staged approach based on case studies in Sentinel Asia", *International Journal of Disaster Risk Reduction*, vol. 33 (February 2019. Available at https://www.sciencedirect.com/science/article/pii/S2212420918304801
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h. United Nations, "Sendai Framework for Disaster Risk Reduction (2015-2030)". Available at https://www.preventionweb.net/files/43291_sendaiframeworkfordrren.pdf

Recommendation 3: Manage data and information more effectively

To facilitate widespread data availability and usage, national geospatial databases and the query engines should be hosted on a web-based platform. This platform could be deployed as a server cluster or as a cloud-based solution, allowing it to serve as a regional geospatial data analytics platform. This would bring together countries within the region to make data more accessible and available through sharing and collaboration. Hence, to achieve maximum benefit, it is essential that all member countries adapt and advance their geospatial tools and applications.. Necessary capacity-building could be facilitated by other member nations through ESCAP, as required. At the twenty-sixth session of the ICC, China and Japan offered capacity-building opportunities to help countries in using cloud technologies.[5]

At the national level, action is needed to develop and foster greater capacity for institutional collaboration, interoperability and integration across the various national data information systems, platforms, and policy processes. The United Nations Integrated Geospatial Information Framework, adopted by the Committee of Experts on Global Geospatial Information Management, provides a basis and guide for developing, integrating, strengthening, and maximizing geospatial information management and related resources in all countries. Countries are encouraged to develop their country-level action plans their country-level action plans that align with their countries' priorities and circumstances.

Regional cooperation among countries is vital to improving the integration of geospatial information according to commonly-shared principles, formats and eventually standards, for enhanced inter-country comparability. At the online regional workshop for promoting the Asia-Pacific Geospatial Information Platform, in October 2020, leaders recommended strengthening regional cooperation to promote the sharing and use of geospatial information among countries in the region. The participants strongly supported the effective use of integrated geospatial information among ESCAP members and associate members through enhanced regional cooperation under the auspices of the United Nations Initiative on Global Geospatial Information Management.

Similarly, the Regional Committee of United Nations Global Geospatial Information Management for Asia and the Pacific, at its ninth and tenth plenary meetings, held from 3 to 5 November 2020, and 2 to 4 November 2021 respectively, recognized in a resolution the need to provide member States with a regional integrated geospatial data hub and a geospatial information-statistics integration platform to leverage innovative methodologies and develop common data sets, tools and multi-country common methodologies for big data analysis and evidence-based decision-making.

Countries, in the region, could endorse the initiation of technical feasibility studies to explore the most effective models of sharing geospatial data with each other with the aim of making them accessible, affordable, available and actionable in support of sustainable development. Such studies could cover the principles of data sharing, governance and institutional arrangements, as well as implementation modalities aligned with Economic and Social Council resolution 2016/27 on strengthening institutional arrangements on geospatial information management. In this resolution, the Council stressed the need to strengthen the coordination and coherence of global geospatial information management in capacity-building, norm-setting, data collection, data dissemination and data sharing, among other areas, and acknowledged the importance of strengthening capacity-building in the area of geospatial information management and relevant statistical integration, especially in developing countries.

Recommendation 4: Enhance partnerships with national, regional and global stakeholders

Through implementation of the Plan of Action, collaborative actions between members and associate members, entities in the United Nations system, regional and international institutions, the private sector and other stakeholders have been strengthened.[6] Such cooperation could be further strengthened by increased harmonization of relevant initiatives and enlarging the base of stakeholders around a common theme.

As part of the efforts to accelerate the Phase II implementation, greater coordination among existing mechanisms and more partnerships with ESCAP are needed. These include the United Nations Satellite Centre, the Committee of Experts on Global Geospatial Information Management, the United Nations Platform for Space-based Information for Disaster Management and Emergency Response, the Asia-Oceania Group on Earth Observations, the United Nations University, the Asia-Pacific Space Cooperation Organization, the Asia-Pacific Regional Space Agency Forum, the Centre for Space Science and Technology Education in Asia and the Pacific, the ASEAN Research and Training Centre for Space Technology and Applications, Multi-GNSS Asia and the Asian Institute of Technology.

Furthermore, new partnerships could accelerate the implementation of Phase II of the Plan of Action. For example, while the sharing of satellite imagery for post-disaster monitoring and response is a well-established practice in the region today, cooperation on ex-ante disaster risk management could be expanded. One concrete action that is being pursued is the development of a virtual constellation of satellites for better anticipation of disasters that continuously share high-resolution satellite imagery related to disaster risk hotspots with countries in special situations. The focus could be on high-risk disaster areas, such as flood and wildfire hotspots. In addition to accessing satellite imagery, capacity-building to integrate satellite-derived data with socioeconomic data (for example, the socioeconomic profile of low-income households or businesses located in these hotspots) is important as it can produce insights that improve anticipatory reduction of risks and help on ex-post disaster recovery and relief (Box 5.3).

Recommendation 5: Enhance the complementarity between the implementation of the Plan of Action and the work of relevant ASEAN bodies

Within ASEAN, the Sub-Committee on Space Technology and Applications (SCOSA), under the ASEAN Committee on Science and Technology,[7] serves as the main platform to formulate and coordinate collaborative and cooperative programmes and projects on space science and technology. Space technology applications is one of the main priority areas of SCOSA for 2016-2025. A number of the identified thematic areas are the same as the identified priority areas of the Plan of Action, including disaster risk reduction, climate change, agriculture, environment and resource monitoring. Serving as the current chair of SCOSA, Thailand has successfully ensured the linkages between the two.

Opportunities for supporting the space applications for sustainable development could be expanded through the work of other ASEAN bodies, such as the ASEAN Committee on Disaster Management. For example, the Regional Drought Mechanism is an example of how innovative digital applications could be customized for each country to support the implementation of the recently-adopted ASEAN Regional Plan of Action for Adaptation to Drought 2021-2025.[8] In Thailand, for example, the application programming interface between CropWatch Cloud and AgriMap farming system enables real-time sharing and interactive access to ground observation data, farming conditions and farming climate indicators. This enables early detection of crop growth abnormalities and possible crop failure.

Concluding remarks

The Asia-Pacific region took a major step forward with the adoption of the Plan of Action at the Third Ministerial Conference on Space Applications for Sustainable Development held in Bangkok in 2018. This adoption demonstrates the commitment to solidarity of Asia-Pacific countries, and their capacity to undertake large-scale collaboration to advance the achievement of SDGs through space and geospatial information applications.

The Fourth Ministerial Conference on Space Applications for Sustainable Development in Asia and the Pacific, to be convened in Jakarta on 26 October 2022, is an excellent opportunity to both renew commitments and initiate large-scale collaboration to accelerate the implementation of the Plan of Action as it enters Phase II of its implementation. The outcomes of the Conference are expected to create the conditions and capacity to initiate national and regional level policy actions described in this chapter. Follow-up on such actions would be important in supporting the efforts of South-East Asia to accelerate progress on the Sustainable Development Goals.

Endnotes

1. Klaus Schwab (2016).
2. Tatiya Chuentragun (2022).
3. For more information on Indonesia and Thailand's FloodAI project, see Chapter 2.
4. Centre for Earth Observation.
5. ESCAP (2022).
6. Tadashi Nakasu (2022).
7. ASTNET (2021).
8. ASEAN Secretariat (2021).

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This 2022 edition of the Compendium documents over 60 good practices of the use and application of geospatial information in the public sector, from across several countries in South-East Asia, giving readers a comprehensive overview of how different space-based applications and methodologies have been used across South-East Asia. The compelling practices that are selected, demonstrate the innovative and unique uses of space applications, and which provide clear benefits for users. The prime examples are further analysed from the lens of making geospatial information available, accessible, affordable and actionable.

The depth and range of geospatial practices, featured in this Compendium, are proof of the steady progress that countries in South-East Asia are making towards implementing the Plan of Action on Space Applications for Sustainable Development in Asia and the Pacific (2018–2030) to advance progress on the Sustainable Development Goals.

The Compendium concludes with five policy recommendations for consideration by countries in the region to accelerate the implementation of the Phase II of the Plan of Action with “Space+ for our Earth and future” as its guiding theme. Space+ leverages the strong potential of innovative digital applications, brought by the fourth industrial revolution, offers for the achievement of the Sustainable Development Goals in conjunction with multi-sectoral user engagement; effective management of data and information; and enhanced partnerships.

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