Economic Research Institute for ASEAN and East Asia

Integrated Spaced-Based Geospatial System:
Strengthening ASEAN's Resilience and Connectivity

By
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Foreword

Space and geospatial technology (SGT) are no longer just fields of advanced technological development and scientific research – they have become key components to help achieve sustainable development and strengthen resilience. They can improve the efficiency and resilience of industrial operations and effectively address issues in regional economic integration of the Association of Southeast Asian Nations (ASEAN).

Based on this understanding, the Economic Research Institute for ASEAN and East Asia (ERIA) commissioned the study project 'Applying Space-based Technology for Building Resilience in ASEAN Region' in 2014. The study concluded that geospatial technologies and space technologies have notable potentials to strengthen economic resilience, although the mechanism for integrating these technologies in a sustainable way has still not been well established. The study pointed out the necessity of (i) transborder mechanisms to deliver geospatial and space-based information from data providers to end users in disaster-affected areas, with the support of international activities; and (ii) financial schemes involving the private sector or public–private partnerships (PPP) to enable the collaborative integration of the technologies in sustainable and practical ways.

To implement such a mechanism, it is important to assess the benefits from SGTs and available applications, and conceptualise necessary policies. This report provides the status of SGTs and applications, and their potential benefits to ASEAN, based on past practices in Asia and the Pacific. It includes information about what combinations of technologies were applied and how they contributed to the resilience of ASEAN by key issues, including urban development, infrastructure planning and management, transportation management, improving quality of life, post-disaster management, improving logistics efficiency, sustainable operations of agriculture and fishery, improving efficiency manufacturing and service industry, and management of environmental services and natural resources.

This report also covers policy perspectives with strategy options about how to implement the regional connectivity of ASEAN supported by the technologies, especially focusing on transborder mechanisms of data and information.

We hope that this report proves useful to the participating ASEAN countries and stakeholders who work with ASEAN in guiding the SGT applications towards achieving connectivity in ASEAN.

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List of Abbreviations

AADMER	ASEAN Agreement on Disaster Management and Emergency Response
ADB	Asian Development Bank
AHA Centre	ASEAN Humanitarian Assistance Centre
AI	artificial intelligence
ASCC	ASEAN Socio-Cultural Community Blueprint 2025
ASEAN	Association of Southeast Asian Nations
CORS	Continuous Operational Reference Station
DDMCC	Department of Disaster Management and Climate Change
DRM	disaster risk management
ERIA	Economic Research Institute for ASEAN and East Asia
GDP	Gross Domestic Productgross domestic product
GHG	greenhouse gas
GIS	Geographic Information System
GISTDA	Geo-Informatics and Space Technology Development Agency
GNSS	Global Navigation Satellite Systems
IMRO	Institute for Marine Research and Observation
IoT	Internet of Things
LAPAN	Lembaga Penerbangan dan Antariksa Nasional
MPAC	Master Plan on ASEAN Connectivity 2025
OECD	Organisation for Economic Co-operation and Development
PFG	Potential Fishing Groundpotential fishing ground
QZSS	Quasi–Zenith Satellite System
RTK	Real Time Kinematic Satellite
SAR	Synthetic Aperture Radar
SGT	Space and Geospatial Technology
UNESCAP	United Nations Economic and Social Commission for Asia and the Pacific

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Executive Summary

Optimisation of production processes is the most prioritised issue in industrial factories. Such optimisation is quite feasible because it is easy to acquire all data on environment and boundary conditions that affect production. However, it is a challenge to extend optimisation beyond the factory processes, such as product delivery to consumers and retailers. This is because factories do not have enough information to predict product orders, latency, and incidents during delivery processes from factories to retailers. This causes a lot of uncertainties in optimising the entire production process. For example, more products must be stocked to cope with unexpected fluctuations in product orders, latency, and transportation incidents from factories to retailers. Longer lead time may be needed for product delivery. Larger stocks and longer lead time will inevitably increase cost and cause inefficiency.

Thus, constructing large-scale production systems by connecting a variety of facilities and stakeholders such as factories, deliveries, and retailers is always difficult due to uncertainties arising from the connections of many systems, and may result in the degradation of production efficiency.

Space and geospatial technology (SGT) had been developed as intelligence technology. Space infrastructure, such as satellite observation, positioning and tracking, and communications, helps in enabling more effective decision making by reducing uncertainties and risks through continuous monitoring and visualisation of contextual information on the real world such as people mobility and activity, vehicle traffic, weather, oceanographic condition, and disasters.

The potentials of space infrastructure are rapidly growing along with the successes of small-scale and low-cost satellites. In addition, data infrastructure for big data and artificial intelligent technologies enables rapid integration and analysis of real world dynamics with diverse data resources from satellite observation and positioning and tracking. SGT can also support decision makers to swiftly monitor and accurately predict the situation and changes of people and companies. SGT therefore enables safer and less risky decision-making and activities by providing the dynamic contextual information surrounding industries and people's lives.

In case of heavy rain disasters, rapid areal monitoring of flooded roads and traffic jams helps reduce service latency by changing transport types and routes. Once the

uncertainty in delivery is reduced, shorter production time and smaller stocks could be more easily achieved. Moreover, SGT helps record disaster responses as digital data. Such data makes it possible for artificial intelligence-based analysis to improve responses to future disasters.

SGT-based integration supports the development of large-scale production-delivery systems by integrating many enterprises over various industrial fields, thus reducing uncertainties caused by external factors. As a result, more products and services can be created and delivered in more efficient means.

In the Association of Southeast Asian Nations (ASEAN) region, where many and diverse organisations, enterprises, and people function over a large geographic area, it is very important to achieve 'unbundling'. 'Unbundling' refers to a situation where many diverse communities and companies recognise their own unique roles and connect with each other in the region to produce unique and diverse products and services more efficiently and effectively. SGT should be a critical infrastructure of information sharing for the 'unbundling' of ASEAN.

On the other hand, ASEAN must prioritise people's safety and quality of life. SGT also contributes to improving resilience in the ASEAN region, which is one of the most populated and disaster-prone areas in the world, by providing information for dissemination and navigation against disaster risks.

To proceed with SGT-based integration in ASEAN, the region needs to promote public–private partnership (PPP) on space infrastructure development and support the development of ground infrastructure. Another important factor is establishing data policies that facilitate transborder data transfer and wise use under proper management mechanisms. This report provides recommendations on strategies and frameworks on ASEAN's data policy and space infrastructure development.

CHAPTER 1

Enhancing ASEAN Connectivity through Space and Geospatial Technology

Space and geospatial technology (SGT) is an intelligence technology that enables the global monitoring of a wide range of parameters such as the distribution of facilities and buildings; the movements of cars, ships, aircraft, and people; environmental change; or post-disaster economic development processes. While geospatial technology was originally developed for military and security use, it has been, in recent years, quickly advanced as a general civil technology. It is now widely applied in the field of public services (e.g. disaster response, social infrastructure management, traffic management), business support (e.g. marketing), and personal mobility services (e.g. navigation). The extensive use of low-cost and high-performance mobile devices such as smartphones has further accelerated its popularisation all over the world. Subsequently, the development of the Internet of Things (IoT) and Artificial Intelligence technologies have enabled researchers to conduct deeper analyses and quicker and broader information collection. In this regard, geospatial technology is expected to expand its utilisation and development much further.

This chapter is organised as follows:

1. Define and introduce generally the potential of SGT in various fields.
2. Present the original application of SGT (disaster management) and its wider potential for economic strengthening.
3. Develop more concrete considerations on the use of SGT and data sharing to advance towards a data-driven Association of Southeast Asian Nations (ASEAN).

The Immense Potential of SGT

This section aims to introduce the concept of SGT and briefly present its general applications.

What is SGT?

The rise of intelligence technologies resulted in the development of the following three technological areas of space infrastructure:

- Satellite-based earth observation technology – monitoring occurrences all over the world;
- Positioning technology – measuring and tracking precise positions in real time; and
- Communication technology – connecting almost instantly every single part of the world.

The most important application of space infrastructure (observation, positioning, and communication) is what is called geospatial technology. Geospatial technology is a global information technology that provides services anywhere using dynamic information on physical aspects, socio-economic demographics, and environmental aspects of the world. The technology is very naturally enhanced by space infrastructure, as illustrated in Figure 1, to cover the world in a seamless manner. Therefore, the improvement in the performances of space infrastructure directly leads to geospatial services. It is then primordial to simultaneously advance the research and development, operations, and use of the both technologies. SGT is the combination of space infrastructure with geospatial technology, which constitutes the core of this book.

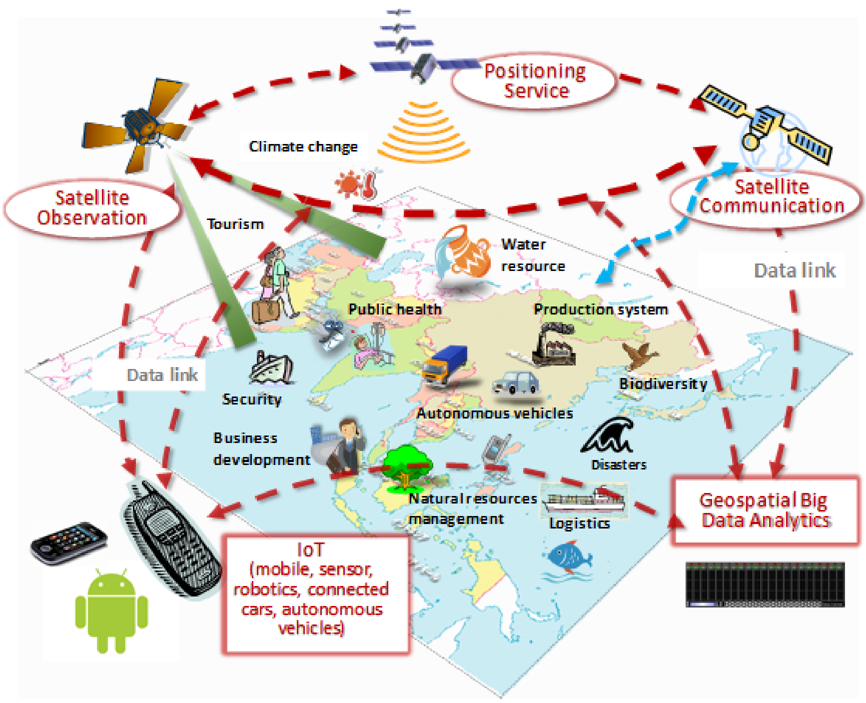
SGT could provide diverse information services using 'real-world data'. More concretely, in the context of this book, the major services and contributions of SGT could be summarised in the following four aspects:

1. Real-time localisation and tracking of people, cargoes, and vehicles (air, sea, and land).
2. Real-time monitoring of environmental and contextual information covering all land and sea such as: dynamic maps (traffic, congestion, people flow, and city changes) or environmental changes (weather, water and air quality, and greenery) from which events, accidents, and disasters

can be extracted. Silent but meaningful changes such as climate change and crustal deformation can be included.

3. 'Ubiquitous' data communication at any time/anywhere with small IoT devices to collect data from and send instructions/guidance to people and machines in the field.
4. High-precision mapping of three-dimensional (3D) space and landscape framing activities of people and autonomous vehicles/machines, which could include very slowly moving phenomena like crust movement monitoring.

Figure 1: Space Infrastructure and Technologies Supporting SGT



IoT = Internet of Things, SGT = Space and Geospatial Technology.

Source: Prepared by the authors.

Satellite observation is extremely flexible and globally applicable compared with the airborne observation performed by aircraft or drones, which are limited by airspace restriction, small coverage, and limited flight time. Real-time positioning by satellites can be performed by compact and inexpensive portable terminals, currently installed in almost all smartphones as well as in most vehicles, airplanes, or ships. Therefore, the mobility data of people, vehicles, ships, and aircraft are widely available.

Geostationary satellites are commonly used for data communication. However, the sufficient miniaturisation of ground transceivers combined with the use of the low earth orbit satellites constellation will increase access to efficient communication and dramatically reduce costs in the near future. Therefore, data communication services or IoT-based data collection and dissemination will be available everywhere, as long as the sky is visible.

Generic example of SGT application

Such a technological environment can be simultaneously established all over the world, allowing the promotion of a broad range of services in various countries and regions.

For instance, small portable terminals equipped with Global Navigation Satellite Systems (GNSS) receivers are commonly distributed on land and sea, such as the smartphones that are widely distributed in most countries around the world. Also, the use of black boxes on most ships and aircraft – devices that combine a GNSS receiver with a wireless communication system, which constantly transmits its position – improved the collection of locational information of commercial vehicles. Finally, the development of IoT has allowed the collection and dissemination of data from various sensors scattered in fields.

As described above, the use of space infrastructure enables us to understand the movements of individual persons, vehicles, and cargoes. Furthermore, satellite imagery analysis helps visualise the background information or reasons behind people's behavioural changes such as traffic congestion, disaster situations, construction of buildings and infrastructure, and changes in agricultural land.

While the easy gathering of production-related information within factories has greatly contributed to the optimisation of production processes, the collection of information related to external environment changes such as traffic jams, people flow, and disasters, was hard to obtain. This is the reason the optimisation of industrial activities and production processes is limited to the inside of factories and not the entire production system consisting of factory networks and logistics. SGT can help collect this kind of information to better understand the overall situation and facilitate tighter cooperation between the various actors of the manufacturing and logistics sectors, leading to optimisation of industrial activities on a broader scale.

Finally, for actors that are mostly involved in outdoor tasks such as construction, agriculture, fishery, and forestry, SGT enables the acquisition of very accurate locational and situational information for further optimisation and automation

The Various Roles of SGT

One of the original targets for the general civil application of SGT is disaster response. Based on an extensive number of previous studies and famous achievements in this field, it has been confirmed that SGT can be applied to the strengthening of the socio-economic system and the development of efficient Disaster Risk Management (DRM) in ASEAN.

In this section, we first examine the use of SGT in the field of DRM and then discuss more generally the importance of data sharing in ASEAN countries.

SGT for disaster management in ASEAN

The Asia–Pacific region, the most populated region on Earth with more than 4.5 billion people, is also the daily theatre of the planet's deadliest disasters. The strong impacts of disasters in the Asia–Pacific region do not simply refer to the intensity of these unfortunate events but also to the set of systemic weaknesses of Asian countries: economic and financial fragility, galloping urbanisation, exploding demography, or lack of proper land use planning.

One of the main reasons for the vulnerability of the Asia–Pacific region to disasters is its demography. According to the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP), the Asia–Pacific is the most populated area in the world, with more than 4.5 billion inhabitants in 2016 (UNESCAP, 2016). The region has most of the world's largest metropolises. In 2016, the United Nations estimated that 18 of the world's 31 megacities (cities with more than 10 million inhabitants) were in Asia–Pacific and that this number is expected to reach 24 out of 41 in 2030 (UNESCAP Population Division, 2016). These high densities of population, often located around riverside flood areas, along coastlines at risk of tsunami, or at the base of landslide-prone mountains, put large numbers of human life in jeopardy.

In its 2015 Asia–Pacific Disaster Report, UNESCAP drew a sad portrait of the region. Between 2005 and 2014, 1,625 incidents had been reported. Most of these disasters were floods, followed, in order, by storms, earthquakes, tsunamis, and landslides.

These disasters had a dramatic impact on the region's human security by killing almost half a million inhabitants and directly affecting the lives of approximately 1.4 billion people (see Table 1). Moreover, beyond long-term economic impact due to the loss of workforce as well as the increase in spending for health-related issues, the 1,625 disasters generated direct economic damage amounting to US$523 billion.

Table 1: Human Impact of Disasters in Asia and the Pacific, 2005-2014

Disaster type	Lives lost	People affected (millions)
Earthquakes and tsunamis	199,418	74
Storms	166,762	321
Floods	43,800	771
Others	73,722	199
Total	483,752	1,366

Source: The Asia–Pacific Disaster Report 2015, Disasters without Borders, United Nations Economic and Social Commission for Asia and the Pacific.

Finally, the UNESCAP report stressed that although these numbers are enormous, they may be underestimated due to a lack of reliable disaster data gathering initiative (UNESCAP, 2015).

Beyond natural disasters, strengthening food and water security is a priority for development organisations operating in the region. According to an Asian Development Bank (ADB) report on food security, in 2010 more than 700 million people in the Asia–Pacific survived on less than US$1.25 per day in an environment where high and volatile food prices caused 537 million of these people (62% of the world population) to suffer from hunger (ADB, 2013). Moreover, as 80% of water resources are still exclusively used for agriculture, the region is particularly affected by water insecurity: 1.7 billion people do not have access to basic sanitation, 80% of wastewater is directly dumped into rivers, lakes, or seas with almost no treatment (ADB, 2016). In terms of economic development, it is estimated that the annual global cost of water insecurity is US$500 billion, corresponding to a loss of more than 1% of global gross domestic product (Sadoff et al., 2015). It goes without saying that the dramatic advance and intensification of climate change will considerably amplify all these issues as well as many others, including water level increase, desertification, scarcity of available water resources, climate refugees/migrations, or the intensification of large-scale meteorological disasters. Finally, the United Nations Children's Fund recently raised an alarm about the increasing dangers posed by air pollution. According to the UN agency's data, more than two billion children live in areas where outdoor air pollution levels exceed the World Health Organization's guidelines, including 1.07 billion in Asia–Pacific. Moreover, every year air pollution kills 600,000 children under 5 years old.

It is therefore very important for ASEAN to develop and implement ambitious disaster risk management policies and strategies based on SGT. The following steps describe how SGT will contribute to DRM via real-time tracking, monitoring, mapping, and ubiquitous data communication capabilities:

- Monitoring and forecasting hazards at the local to regional scale, typically heavy rainfall, flooding, typhoon, drought, and tsunami, allowing governments and people to know what could happen.
- Anticipating risks or damage to human lives and economic activities by overlaying the hazard prediction on the data of people distribution/activity information, vehicle movement, and economic activity distribution/intensity.
- Mitigating damage by guiding the evacuation of people based on people distribution data and helping in the reconstruction of people's lives and economic activities.
- Improving preparedness by providing realistic simulations and trainings on DRM based on the historical records of disasters and reconstruction processes.

The capabilities described above are made possible by sharing data amongst governmental agencies, private industries, non-profit organisations, and people. In this regard, SGT and more generally data sharing can play a prominent role, as clearly stated in the ASEAN Agreement on Disaster Management and Emergency Response (AADMER) Work Programme 2016–2020 (ASEAN Secretariat, 2016):

> *Promote regional standards, including methodologies and tools to assess, record, calculate the disaster losses and damage, and share non-sensitive data and create common information system to enhance interoperability, ensure unity of action, and strengthen resilience.*

It should therefore be smartly and strongly designed, not only for disaster management, but for multipurpose uses, aimed at strengthening the regional socio-economic environment. Furthermore, beyond the impact of the system, it should be made in an economically sustainable way, which is a significant challenge.

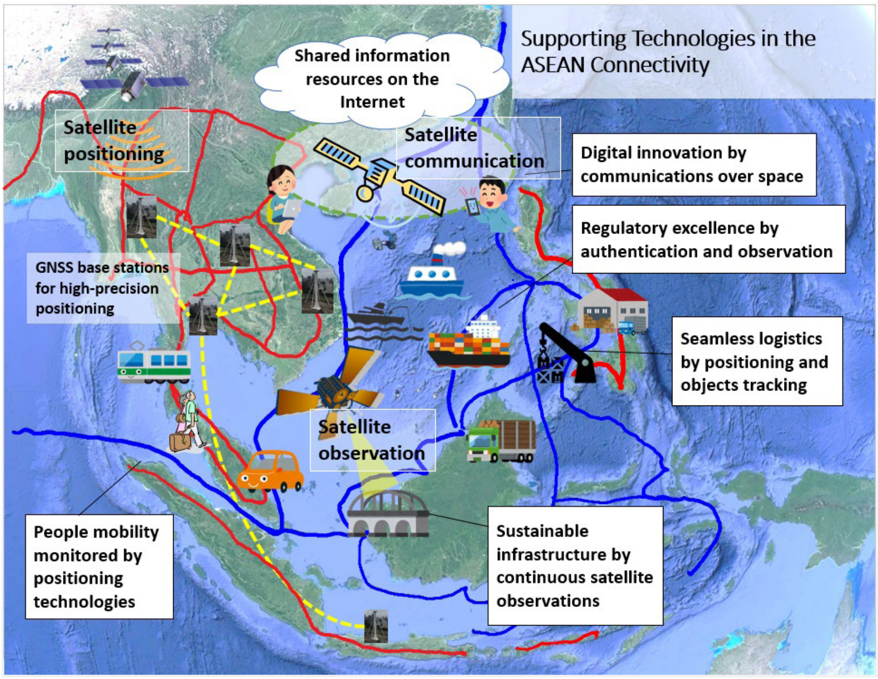
SGT for economic strengthening through enhanced connectivity

As explained above, the potential of SGT incites users to go further than immediate issues like disaster by using it as an ambitious tool at all levels of the economy.

SGT largely contributes to decision-making processes amongst governments, companies, communities, cities, and individuals in various contexts by providing necessary information. As SGT enhances the economy and facilitates 'smartification' or 'optimisation' across various kinds of 'borders', such as the border between the inside and outside of a factory, and borders amongst companies and regions/countries, it is extremely effective to connect all actors of ASEAN more tightly. Therefore, this study examines the possible contributions of the SGT system and data infrastructure to strengthen ASEAN connectivity.

Furthermore, strengthening ASEAN connectivity is also essential for the cross-border utilisation of SGT. Therefore, the study also provides policy recommendations aimed at the enhancement of ASEAN connectivity, such as transboundary data transfer policy to maximise the use of SGT.

Figure 2: Supporting Technologies in the ASEAN Connectivity



ASEAN = Association of Southeast Asian Nations, GNSS = global navigation satellite systems.

Source: Prepared by the authors.

Therefore, this book addresses a common platform and infrastructure of SGT to enhance ASEAN connectivity and help realise human development, resiliency, and sustainable development. The sustainability of the system will reside in its value-creation process.

The approach of this book is perfectly in line with the ambitious Master Plan on ASEAN Connectivity 2025 or MPAC-2025 (ASEAN Secretariat, 2016). Adopted in 2016, it targets the following sectors as main contributors to ASEAN connectivity strategies: sustainable infrastructure, digital innovation, seamless logistics, regulatory excellence, and people mobility. SGT can contribute to these strategies by addressing common issues, developing common interests, and creating common infrastructures.

In addition, in the ASEAN Socio-Cultural Community Blueprint 2025 or ASCCB-2025 (ASEAN Secretariat, 2016), SGT is expected to make ASEAN more:

- Sustainable through its application to biodiversity conservation, climate change, urbanisation, production, and consumption.
- Resilient through disaster response and health care.
- Dynamic through science and technology development.

These strategies and solutions can be efficiently expanded to the entire ASEAN region, thanks to the extensiveness, immediacy, and transboundary nature of space technologies.

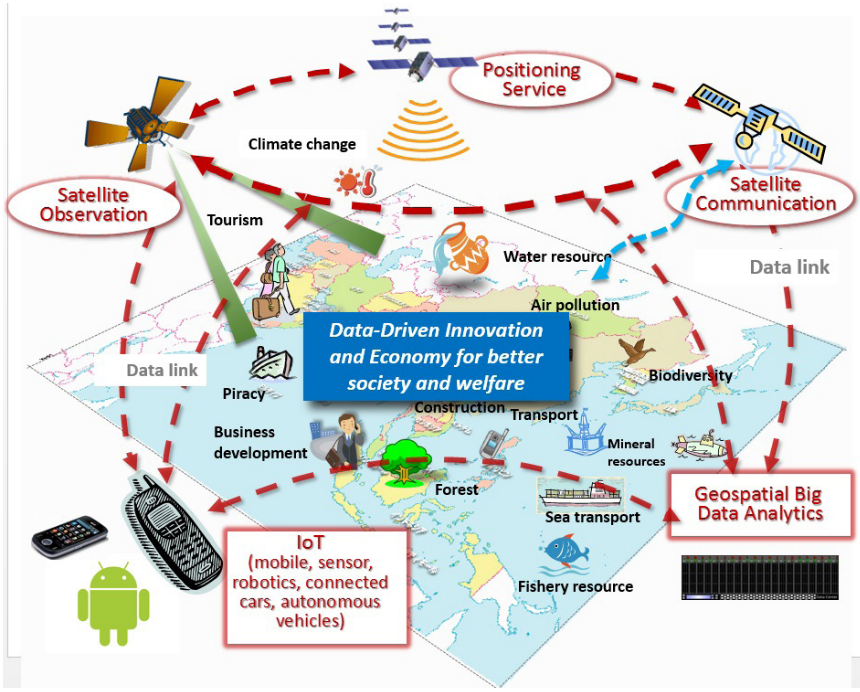
Specifically, while levels of ground infrastructure maintenance greatly vary with the degree of economic development, a space system can provide the same information and services to the whole region. Therefore, strategies and good practices obtained from MPAC-2025 and ASCCB-2025 can be freely applied to ASEAN countries by overcoming national infrastructural limitations.

Towards a Data-driven ASEAN

At the end of 2015, the Organisation for Economic Co-operation and Development (OECD) published a major report entitled Data-Driven Innovation – Big Data for Growth and Well-Being. It stated that 'digitalisation' and data conversion of various activities will advance innovation, and that a new economy will be developed accordingly (OECD, 2015).

The existing common infrastructures (communication and meteorological satellites) and the traditionally dynamic interactions (trade, information sharing, and interaction) in the ASEAN region make ASEAN the perfect place for the emergence of the upgraded version of data-driven innovation economy (DDIE). By removing physical restrictions, SGT will support ASEAN transformation into a DDIE 2.0.

Figure 3: Data-Driven Innovation and Economy through SGT



IoT = Internet of Things, SGT = Space and geospatial technology.

Source: Prepared by the authors.

The tremendous economic potential of SGT

To better understand the prominent role that could be played by SGT in promoting innovation in ASEAN, let us look again at MPAC-2025. In its focus on digital innovation, it claims that:

Disruptive technologies (particularly mobile Internet, big data, cloud technology, the Internet of Things, the automation of knowledge work and the Social-Mobile-AnalyticsCloud or SMAC) could unleash some US$220 billion to US$625 billion in annual economic impact in ASEAN by 2030 (ASEAN Secretariat, 2016).

In other words, it is SGT that will help unleash these hundreds of billions of US dollars, which may be generated from increased efficiency, new products and services, and much more.

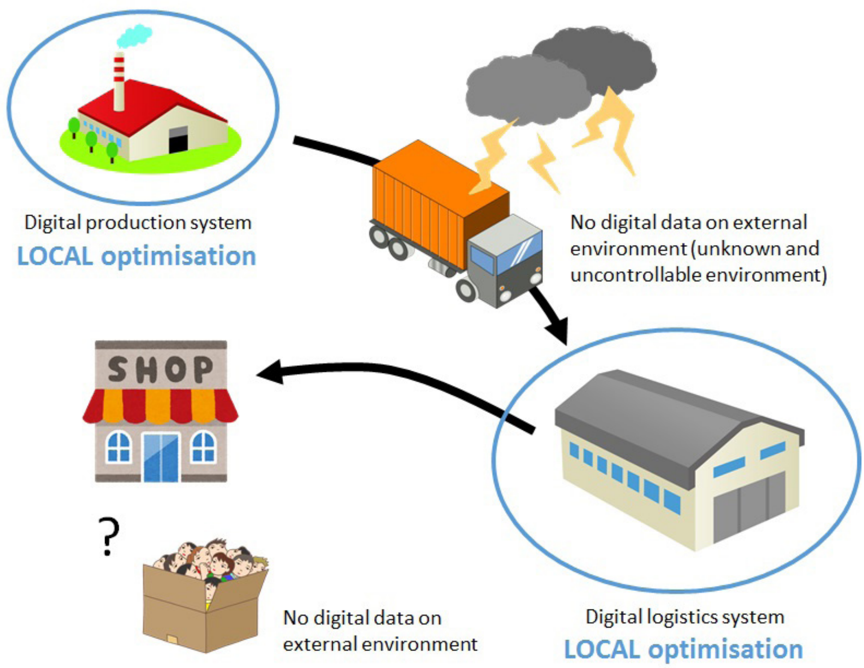
From local to global optimisation

As briefly explained above, one of the greatest strengths of SGT is its capacity to go beyond local optimisation, at factory level, to achieve global optimisation – considering dynamically changing external factors and interrelations.

The use of digital technology for monitoring and control within factories is already well developed, allowing an optimal use of resources and means of production for the production system in a factory.

However, information sharing such as logistics between the factory and its partners (distributing networks, providers, etc.) is very insufficient. Any logistical irregularity will impact the whole production system independently from the quality of the local optimisation within the factory.

Figure 4: Local Optimisation



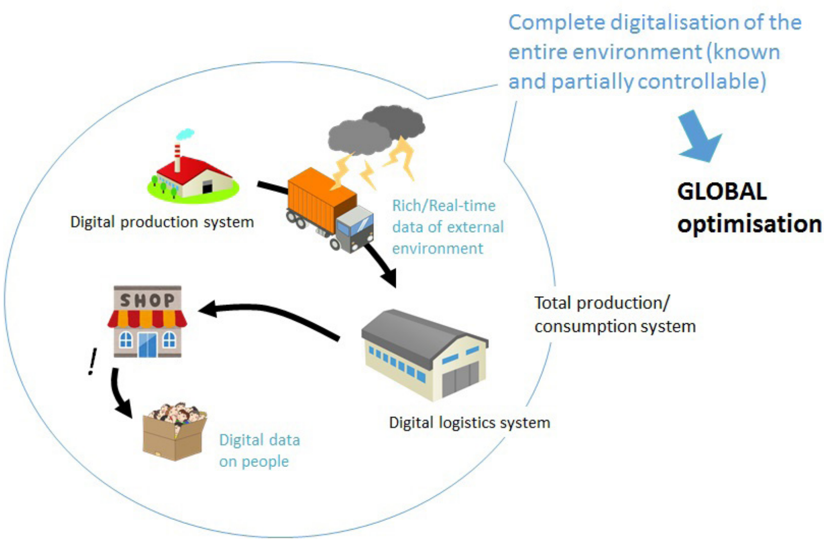
Source: Authors.

Therefore, changes in the external environment can be major risks when data cannot be obtained, showing the limits of local optimisation, as described in Figure 4. While the external environment cannot be directly controlled, if real-time data can be obtained, the production system can be adapted to the changes and the risks can be significantly reduced.

Furthermore, in sectors organised around outdoor activities, such as construction, agriculture, forestry, and fishery industries, sufficient information required for production cannot be easily obtained.

SGT seamlessly digitalises all spaces including external environments. It is therefore possible to optimise the entire system by considering external environmental changes. Figure 5 expresses this idea.

Figure 5: Global Optimisation

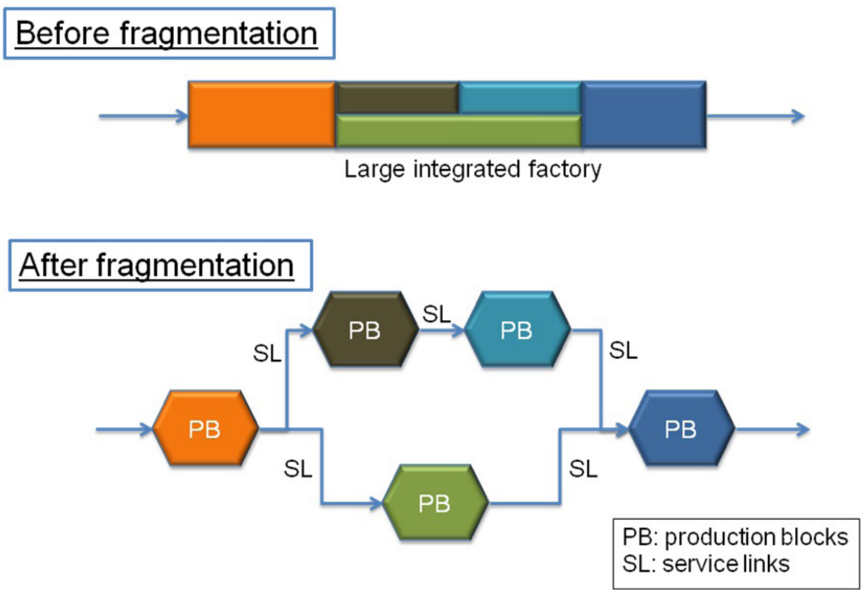


Source: Authors.

Achieving the third unbundling

In the current ASEAN situation, without widespread SGT applications, the optimisation process of the whole production system connecting companies is extremely complicated as the external environment is largely unknown. As a result, companies try to optimise their own production as much as possible by incorporating into a single organisation (e.g. factory) all productive actors, thereby drastically reducing unbundling. Figure 6 shows the concept of unbundling in production and industrial systems.

Figure 6: The Concept of Unbundling



PB = production blocks, SL = service links.

Source: Comprehensive Asia Development Plan Research Team, Economic Research Institute for ASEAN and East Asia.

However, if sufficient digital data on the external environment are obtained, it is possible to control the whole production system for optimisation by incorporating the external changes. As a result, it is not required to build up each component of a production system in the company. Unbundling of the production system can be advanced to a large scale.

While a change in logistics, thanks to SGT, accelerates the second unbundling – the spatial separation of production blocks – it is expected that the spatial separation of engineers and managers involved in the production will also be further accelerated. This third unbundling will be achieved through the digitalisation of production systems, which is the digitalisation of people, goods, and real-time monitoring.

Conclusion: Enhancing ASEAN digitalisation and connectivity with SGT

In summary, data-driven innovation as proposed by the OECD is a general concept stating that industrial innovation will be developed through data utilisation.

On the other hand, SGT effectively facilitates the optimisation of the whole economic system – production, consumption, services, etc. – by digitalising the external environment of individual production and business activities.

In ASEAN, where sudden external environmental changes, such as disasters, frequently occur, DDIE associated with SGT plays a significant role. Understanding such changes is not only important for the optimisation of production systems but is also essential for improving social welfare, including life stability and safety of local populations.

It can therefore be said that SGT will rapidly strengthen the interconnectivity of ASEAN countries. As a result, it will strongly support industrial innovation, economic advancement, and social welfare.

In short, SGT will create immense value through the realisation of the Data-Driven Innovation and Economy 2.0 and the Third Unbundling in ASEAN.

CHAPTER 2

Innovative SGT for the ASEAN Economy

Following general considerations on the potential of space and geospatial technology (SGT) in Chapter 1, this chapter will present concrete areas of application of SGT in ASEAN and is divided into the following sections:

1. General role and potential of SGT;
2. Presentation of key areas of application of SGT to the ASEAN economy; and
3. Concrete recommendations based on the key areas introduced in Section 2.

The Role of SGT

As described in the previous section, SGT consists of four aspects:

1. Real-time localisation and tracking of people, cargoes, and vehicles (air, sea, and land).
2. Real-time monitoring of environmental and contextual information covering all land and sea such as: dynamic maps (traffic, congestion, people flow, and city changes) or environmental changes (weather, water and air quality, and greenery) from which events, accidents, and disasters can be extracted. Silent but meaningful changes such as climate change and crustal deformation can be included.
3. ‘Ubiquitous’ data communications at any time/anywhere with small Internet of Things (IoT) devices to collect data from and send instructions/guidance to people and machines in the field.

4. High-precision mapping of three-dimensional (3D) space and landscape framing activities of people and autonomous vehicles/machines, which could include very slowly moving phenomena like crust movement monitoring.

For aspect 1, it is technically possible to track most of the locational information of cars and people with the use of the widely distributed smartphones. However, the collected data are often scattered, and neither shared nor well exploited. Regarding aspect 4, the Quasi–Zenith Satellite System (QZSS) will start full operation in 2018, and seven satellites will be operated in 2023. Along with these developments, reinforcement service for high-precision positioning such as MADOCA will be provided; and more accurate location information can be obtained. As a result, location information can be rapidly applied in various fields such as automatic driving and tracking of ground movement. Regarding aspect 3, an integration of various information covering people and cars in mega cities and interior areas, including oceans and rural communities, can be achieved with the help of IoT sensor networks and machine-to-machine (M2M) communication network developments. Indeed, 'OneWeb', the data communication service with global coverage and with 648 low-altitude satellites, will provide a satellite Internet network to the entire world by 2020. Regarding aspect 2, based on the PLANET and AXELGLOBE plans, typical emerging satellite observation companies deploying constellations of small satellites, real-time monitoring of the entire globe can be achieved within a few years.

These four principal functions are supposed to be implemented by 2025. Therefore, as described in the previous section, it is necessary to discuss the 2025 infrastructure strategy in the Master Plan on ASEAN Connectivity 2025 (MPAC-2025), and the sustainability, toughness, and innovation of the ASEAN Socio-Cultural Community Blueprint 2025 (ASCCB-2025) associated with the current technological innovations.

ASEAN countries face many challenges. For example, economic development and population growth in the region are remarkable. Furthermore, there is enormous potential for socio-economic developments resulting in excellent human resource developments. On the other hand, the shortage of infrastructure investments, traffic congestion, environmental destruction, urban problems, and income disparity have been severely deepened.

Risks of natural disasters such as storms, floods, earthquakes, tsunamis, and landslides are also very high. Therefore, a huge investment is required for proper disaster management. Transportation network developments connecting countries and socio-economic developments are still insufficient. Investments of US$16.6 trillion for road development will be needed by 2030 (Dobb et al., 2013).

SGT provides essential information on disaster response, expansion and strength of international transportation networks, reduction of traffic congestion, optimisation of logistics, and comprehensive urban management; and strengthens the Plan-Do-Check-Act (PDCA) cycle.

The Expected Contributions of SGT

The significant contributions of SGT in addressing social issues are summarised as follows:

1. Better urban development/control, including sound financial basis;
2. Better infrastructure planning and management, including financing;
3. Better, safer, and smoother transportation systems;
4. Better quality of life by reducing costs and risks from disaster, accidents, and diseases; and increasing job and financing opportunities;
5. Better disaster responses, evacuation, and recovery;
6. More efficient and secure logistics;
7. More stable, profitable, safer, and sustainable agriculture and fishery while conserving resources and the environment;
8. More efficient manufacturing and service industries supported by better logistics and transportation systems; and
9. Better quantification and management of environmental services and national resources.

Better urban development control, including more sound financial basis

Information, such as stagnation and movement of people and vehicles, urban facilities developments, and construction of houses and infrastructures such as roads, can be continuously provided by SGT. Therefore, governments and local communities can conduct proper policymaking and monitoring, aimed at urban planning, urban growth management, and environmental improvement in an efficient way. For example, individual information on stagnation and movement condition of people and vehicles can be used for introducing new taxes such as congestion pricing and space use charge. Furthermore, extraction of buildings and land uses, and their changes from satellite imagery can be used for strengthening building taxation and land tax levies. To apply location information for taxation, it is necessary to implement a location authentication system to prevent spoofing.

Better infrastructure planning and management, including financing (road pricing, etc.)

Infrastructural conditions can be detected in timely fashion through image analysis and sensor information. This will contribute to the prevention of accidents caused by infrastructure damage, and to the optimisation of maintenance methods and timing of infrastructure constructions. Real-time digital data on vehicles and people using transport infrastructure will help improve the optimisation of infrastructure investment and the overall optimisation of infrastructure management, including operations. For instance, an infrastructure usage-based charging system can be applicable. As a result, new resources and budgets for infrastructure management can be secured in addition to the better use of limited infrastructure resources. To apply location information for taxation, it is necessary to implement a location authentication system to prevent spoofing. Authentication can also be made possible using encrypted signal broadcasting from satellites.

Similarly, real-time supply and consumption of energy can be monitored as digital data. It will also contribute to the optimisation of energy infrastructure operation and then investment, and finally lead to overall optimisation. In the field of renewable energy, where fluctuations of energy production are quite dominant, more detailed and reliable data on natural environments causing fluctuations can be obtained by SGT, leading to the significant reduction in risks.

Better, safer, and smoother transportaion system

In the transportation system, SGT can track locations of vehicles, passengers, and cargoes. This will help in real-time performance monitoring of transportation systems (smoothness, efficiency, and safety). SGT can easily detect problems and help continuously improve the system in combination with performance monitoring. Furthermore, automatic operation and sharing of vehicles can be performed by using real-time positioning service, which dramatically improves the efficiency and smoothness of the transportation system. It also provides the possibility to simultaneously improve uneconomical external factors such as traffic congestion, air pollution/noise, and greenhouse gas (GHG) emissions. Improvements in traffic congestion greatly contribute to the improvement of productivities (e.g. service industry) by shortening traveling time in cities. Moreover, freedom of location (houses and shops) in towns can be significantly improved, enabling city expansion and improving competitiveness. To secure the safety of automatic operation, the improvement of the security of positioning service is necessary.

Better quality of life by reducing costs and risks from disasters, accidents, and diseases, and increasing job and financing opportunities

Collection and provision of real-time disaster information by SGT efficiently help reduce disaster risks. SGT significantly contributes to improving the quality of life in Asia where disasters generate huge numbers of victims. Also, risk information such as regarding traffic accidents and diseases can be provided as a temporal/spatial distribution so that these risks can be effectively reduced. The outbreak of epidemic diseases could be better controlled with SGT, through monitoring people and patient movement, together with environmental data to estimate the distribution of vectors like mosquitoes.

Furthermore, collecting credit information for micro credit could be made easier and more reliable, providing evidence of an individual's mobility pattern, social networks, and mobile payment data. This system contributes to increasing employment opportunities, such as matching for temporary work. Also, the quality of life of people in terms of safety and income can be continuously traced and evaluated so that continuous improvement can be carried out through the PDCA cycle.

Better disaster response, evacuation, and recovery

The use of SGT helps to quickly and exhaustively detect hazardous areas during disasters such as floods, landslides, earthquakes, and tsunamis. Therefore, evacuation can be promptly carried out in zones with high risks, leading to a substantial reduction of possible damage. Moreover, knowledge of the distribution and condition of evacuees facilitates the efficient provision of medical services and distribution of necessary items to the victims.

Furthermore, SGT allows the monitoring of post-disaster activities such as rebuilding or economic recovery in affected areas. The continuous and detailed assessments of disaster response and recovery activities help provide timely and appropriate support at suitable stages. Moreover, problems can be continuously discovered and solved through the PDCA cycle.

More efficient and secure logistics

The use of SGT enables the tracking of movements of cargoes, vehicles, and ships in real time so that a reliable and continuous evaluation of transport and logistics performances can be made, leading to a significant reduction of the cost and duration of transportation.

In case of disasters and failures, logistical delays can be forecast. Therefore, damage can be reduced by adapting the production amount and the distribution process. Moreover, damage to roads can be detected in advance, so delays and losses of logistics can be minimised by rearranging routes and transport methods. By combining trajectory analysis and location verification, deliveries of products to recipients can be confirmed, leading to secure logistics without theft or illegal sales during the process. Acquiring detailed information such as routes also enables companies to better manage the quality of their products (e.g. refrigerated items and fragile objects). Furthermore, the automation of cargo handling machines during transfers from ships to trucks using secured high-precision positioning services has been developed. This contributes greatly to improving efficiency and reducing cost and time during operations, especially considering the very large geographic range of ASEAN.

More stable, profitable, safer and sustainable agriculture and fishery while conserving resources and the environment

In the agriculture industry, the use of SGT helps in the understanding of the details of agricultural production systems, including growing processes and crop management practices. It contributes to improving agricultural operations, reducing the risks of production, and improving/stabilising productivity and profits. More importantly, the accumulation of these data and integrating them into weather and market predictions can significantly contribute to risk reduction and production optimisation at a higher level. In addition, purchasing insurance can further reduce possible risk. Governments and agricultural market personnel can reduce agricultural impacts by controlling market fluctuations through arranging the stockpile and adjusting imports and exports based on production forecasts. Furthermore, from the viewpoint of management of land and water uses, SGT can contribute to the examination of proper resource use in agriculture (cultivation, products, water use, etc.) and forestry. Thus, necessary improvements can be carried out accordingly.

In the fishery industry, the use of SGT enables the checking of detailed conditions of sea and fishing boat operations, the estimation of the catch amount, and the understanding of the status of fish resources and fish farm operations. This improves fishery operations and reduces risks of production and maritime accidents, leading to an improvement and stabilisation of productivity and profits. Furthermore, entrance fees and charges/regulations based on resource use can be applied in the operation, leading to sustainable use of resources as well as ensuring funds for resource management. Accumulating these data and integrating them with the predictions of sea, weather, and market can contribute to risk reductions and production optimisation. In addition, purchasing insurance can further reduce possible risks. Governments and marine products market personnel can reduce risks by controlling market fluctuations through arranging the stockpile and adjusting imports and exports based on the production forecasts. And from the viewpoint of fishery resources and coastal environmental management, SGT can contribute to the examination of proper resource uses in terms of operation and coastal area utilisation (water quality management, topography modification, and protection of mangroves), and its improvement, if necessary. To apply location information for developing charging systems and regulations, a location authentication system must be implemented to prevent spoofing.

More efficient manufacturing and service industries supported by better logistics and transportation systems

The use of SGT can improve efficiency and safety in logistics, and reduce distribution cost and transportation time, leading to the reduction of production costs in the manufacture, service, and construction industries. Furthermore, allocations of production bases and branches will be flexible. As a result, unbundling of production, distribution, and consumption will be further promoted. Especially in the construction industry, uncertainties in procuring materials, equipment, and labour will be reduced, leading to efficient process management and lower construction costs. As a result, arrangements in production and logistics bases will be further optimised in ASEAN countries. Consequently, management styles, such as company size expansion, will be more flexible. An improved traffic system will also facilitate the flow of people, expand living areas such as shopping and commuting areas, and easily attract tourists. This will lead to the expansion of industries and revitalisation of the regional economy. The competitiveness amongst ASEAN countries will be further improved.

Better quantification and management of environmental services and natural resources

The development of SGT will enable the understanding of details in a quantitative way, including the amount and distribution of environmental services and natural resources. This helps governments and companies to more rationally conduct decision-making by considering a balance between development, use, and conservation. In addition, as the use of environmental services and natural resources can be understood, countermeasures can be immediately taken against inappropriate use. Furthermore, introducing a charging system further promotes its appropriate usage. This process strongly secures financial resources for environmental resources management. Thus, sustainable and adequate environmental services and use of natural resources can be achieved through system development.

Concrete Recommendations and Example of Efficient use of SGT

This section presents concrete recommendations for the application of SGT for the enhancement of the ASEAN economy.

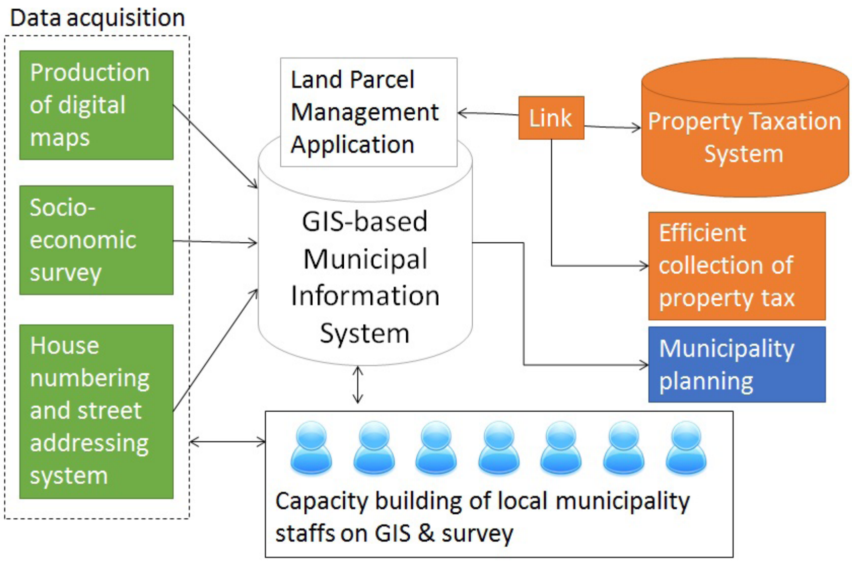
Make cities smarter

The key points in applying SGT to city management are: 1) to reinforce the financial basis of city administration by monitoring land/space values and city infrastructure uses; and 2) to share information on use of city resources like roads and building spaces to facilitate sharing and improve efficiency of usage. It could be accompanied by taxation and rewards

- Greater efficiency and effectiveness in taxation of land and fixed properties by monitoring constructions, vacant land, and land use from space.
- Better and more efficient cadastral surveys by providing basic information for taxation, such as land property.
- Availability of 24/7 monitoring of urban transport (including passengers and cars) to enable choosing less congested routes and efficient transportation, minimising confusion/congestion when events/accidents occur.
- Charging car drivers and pedestrians for congestion time and at congestion places. In addition, charging road parking, street stalls, and disposals to control use of urban space and infrastructure. Then, increasing the financial resource for urban management, while achieving more efficient use of urban facilities/spaces.
- Promotion of sharing economy by frequent (daily/hourly) monitoring of parking, offices, and accommodation. Greater efficiency in the use of urban spaces.

An example is the use of the geographic information system (GIS) application in municipality management in Nepal, which also focuses on the reinforcement of the financial basis through land property taxation. Data on land parcels, including ownership, use, and value are monitored by combining field surveys and aerial/satellite imagery interpretations.

Figure 7: Example of Urban Application of SGT in Nepal



GIS = geographic information system, SGT = space and geospatial technology.

Source: Authors.

Improve the transportation sector

SGT enables the collection and sharing of dynamic information on passengers, cargoes, and vehicles (demand side), and on transportation infrastructure such as roads, railways, harbours, etc. (supply side). Better and safer uses of transportation infrastructure could be facilitated and encouraged by fees and regulations with this information.

- Significant improvement of management and operations by monitoring both the movements of people/cargo and the health of transportation infrastructures/vehicles.
- Better safety through fewer incidents in transportation systems.
- Reduction of disaster damage to transportation systems. Speedy evacuations of passengers and recovery of services.
- Data-driven, evidence-based planning of transportation infrastructure and healthy implementation of plans and operations.
- Flexible adjustment of toll fees (roads, etc.) by location and time. This will contribute to infrastructure development finance and better traffic control.

Improve people's quality of life

To improve the quality of people's lives, top priority should be given to the provision of information on potentially life-threatening risks so that people can avoid them. This should not be limited to disaster and accident risks. Health information can also be regarded as long-term risk information.

The second priority should be provision of information on risks related to convenience, such as the reduction of costs, including time consumed by traffic jams, etc. SGT will contribute to visualising congestions and the like so that people can avoid them. In the longer term, by helping more efficient/effective investment on infrastructure based on reliable information, congestion itself can be mitigated.

The third priority should be enhancing career development and capacity building of individuals. The contribution of SGT here would be limited, though behaviour log data collected through SGT could be used to generate personal credibility information for financing, when traditional credit information is limited.

- Ensure people's security by delivering precise information about disasters and incidents.
- Ensure epidemiological security by delivering precise risk information to people.
- Provide health advice and information personalised according to daily activities and exercise. These will improve the efficiency of public health insurance.
- Reduce commuting time and traffic incidents through better traffic management, to improve the safety and quality of family life.
- Better and more efficient medical and health services by sharing location information of medical service resources such as doctors, nurses, pharmacies, and instruments in situations where there are limited resources.
- More job opportunities and lower unemployment rate by better job matching around home.
- Also, greater safety by avoiding hazardous jobs and better job opportunities.

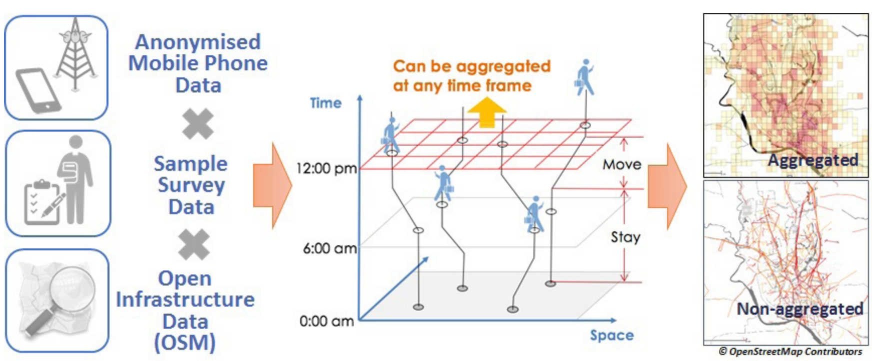
- Diverse education chances through various e-learning systems in ubiquitous network environments.
- Promote community-based assistance through connections by location information and social media. This is very helpful in emergency responses.
- Personal logs of activities and authenticated locations are utilised as proof for individual authentication, anti-identity spoofing, and credit information of finances. It facilitates jobs of start-ups and small businesses via appropriate micro financing systems.

Establish dynamic census

SGT provides new means to complement demographic and economic statistics/indicators that form the basis for better decision-making by stakeholders.

Mobile phones would be the most important devices to collect information on people and their economic/social activities considering the very high penetration in the market. Log data collected through the operation of mobile phone systems could be used not only to complement demographic and socio-economic statistics but also to enhance them because the log data reflects daily activities and movements of people. Figure 9 illustrates how the log data from mobile phones could be used to complement and enhance population census by combining sample field surveys and digital map data created from the satellite imagery. Newly created census could be called 'dynamic census' because it could cover movement and migration of people.

Figure 8: Schematic Description of Dynamic Census



OSM = OpenStreetMap.

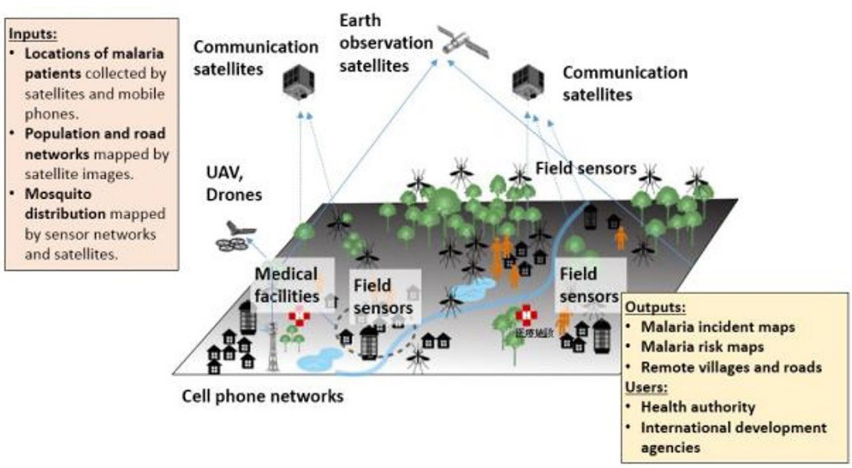
Source: Authors.

The following examples are ongoing efforts to explore new frontiers of applying 'dynamic census' to social problem solving.

Example 1: Space-based Malaria Monitoring and Control

By combining space technologies and ground communications technologies, near real-time mapping of malaria incidents and risks is made, enabling decision-making for malaria control. Overall, malaria risk to people entering high malaria risk areas like forests could be estimated. Dynamic census is used as the basis in the estimation process.

Figure 9: Near Real-time Mapping of Malaria Incidents



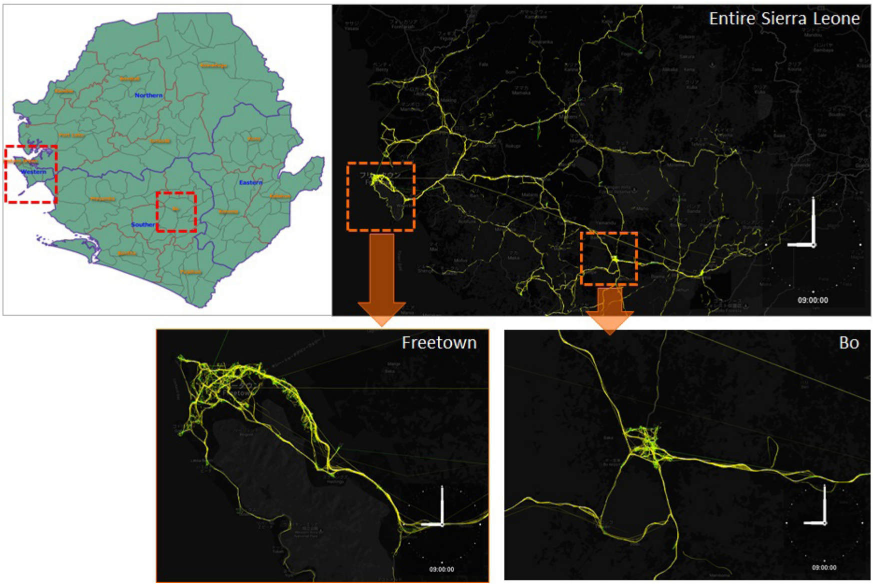
UAV = unmanned aerial vehicle.

Source: Authors.

Example 2: People Monitoring for Ebola Control

In Example 2, the propagation risk of the Ebola virus using the movement of patients and carriers could be readily estimated by using dynamic census or the dynamic monitoring capability of people movement with mobile phone data. Background data for the analysis of people movement can be generated with satellite imageries.

Figure 10: People Movement Monitoring for Ebola Control



Source: Authors.

Enhance resilience

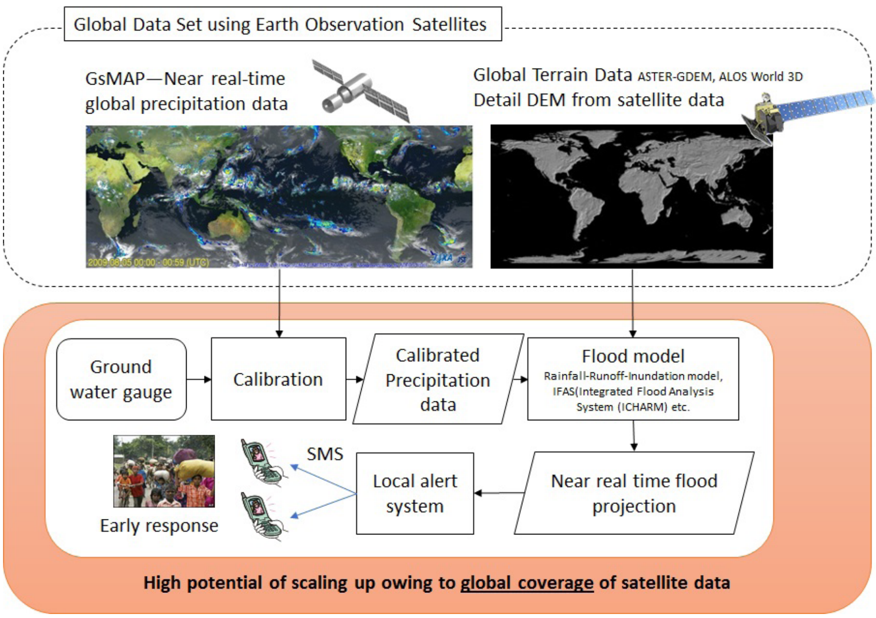
SGT enables the monitoring of ongoing disasters, including how people evacuate, and the forecasting of possible situations and impacts on society. Based on information, people, communities, industries, and societies could mitigate possible damage, more easily recover from damage, learn lessons from past experiences recorded as digital data, and get better prepared for possible disasters.

SGT can:

- Reduce human damage by ensuring rapid information collection and delivery about disaster hazards and damage.
- Ensure goods delivery and debris removal by goods tracking and real-time recovery monitoring after disasters.
- Ensure higher accuracy of forecasts on ground/ocean weather information. Significant improvements are made using satellite earth observation. This provides industry and people with lots of social benefits.

- Secure the safety of people by improving the accuracy of monitoring and forecasting of floods, slope failure, earthquakes, and volcanic eruptions, as shown in Figure 11.

Figure 11: Flood Alert System with SGT

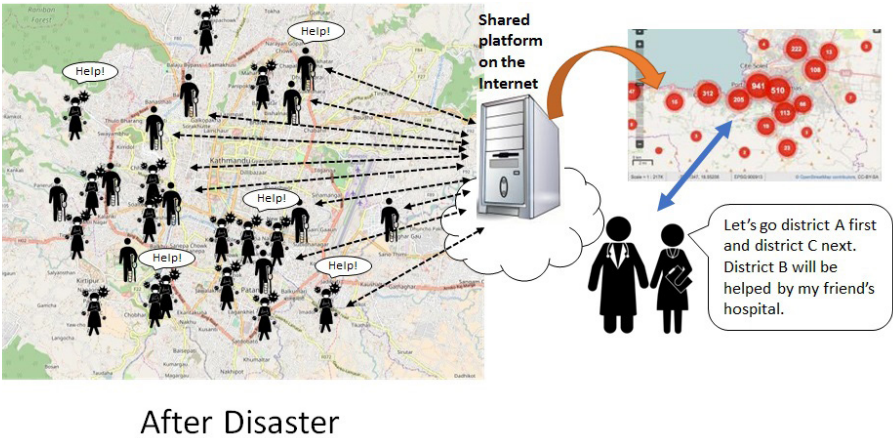


ALOS = Advanced Land Observing Satellite, ASTER–GDEM = Advanced Spaceborne Thermal Emission and Reflection Radiometer–Global Digital Elevation Model, DEM = digital elevation model, GsMAP = global satellite mapping of precipitation, ICHARM = International Centre for Water Hazard and Risk Management, SGT = space and geospatial technology, SMS = short message service.

Source: Authors.

- Disaster nursing supported by SGT. Even after disasters, care for vulnerable people such as babies, mothers, the aged, and injured must be provided. SGT will provide continuous monitoring capability on how vulnerable people suffer and survive so that society can provide the necessary support in a more effective manner.

Figure 12: Supporting Disaster Nursing with SGT



SGT = space and geospatial technology.

Source: Authors.

Improve Logistics

Tracking the movement of things (cargoes, freights) with authenticated position/time information enables the following improvements in the existing logistics systems. However, it should be highlighted that autonomous trucks and convoys could drastically improve the efficiency and safety of road transport of cargoes.

- Certification of production place. More added value by branding and safety, strengthening competitiveness, and leading to more competitive industries and attractive markets.
- Less delivery loss and damage. Smoother and cheaper logistic services. Strengthened logistic networks in remote areas, mountainous villages, and coastal areas.
- Uber-like delivery service by sharing available vehicles and labour that could lead to more efficient and flexible logistic services to fill gaps amongst professional, dedicated logistics services.
- More security and speed in custom clearance through certificates verified by authenticated mobility or location logs.
- Securing the collection, transport, and disposal of hazardous materials (e.g. industrial waste) through movements monitoring. Contribute to environment conservation.

- Reduction of long-distance logistics cost through the convoy transport of autonomous trucks on highways. ASEAN countries should have notable benefits owing to its dependency on road transports.
- Much lower operating cost and transport time through the automation of container handling in harbours.

Strenghten Industrial Activities

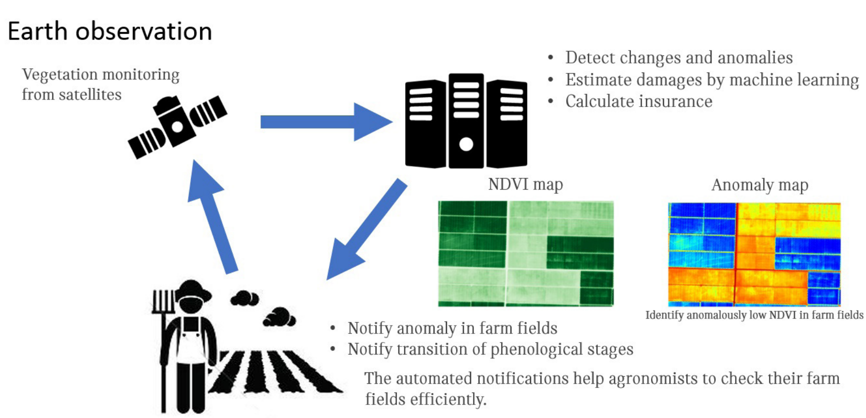
• Agriculture

Agricultural production often suffers from unexpected changes in weather etc. Such environmental changes could be monitored and forecasted using SGT, and farmers could mitigate damage and increase resilience.

– Less damage by preparing for expected typhoons and hazardous weather, as well as adjusting the timing of cropping, harvesting, shipping, and so forth.

– Optimised insurance cost by reducing agricultural risks and less compensation for agricultural damage from public sectors.

Figure 13: SGT for Agriculture



Source: Authors.

• Fishery

Fishery is also very seriously affected by sea conditions. In monitoring and forecasting such conditions, risks could be mitigated. Analysing fish catch and sea condition data enables the estimation of potential fishing ground, which leads to further risk reduction and improvement of fish catch.

– More efficient activities and operations of vessels and port facilities by forecasting harvestable areas and seasons. Better controlled market prices.

– Less impact of oceanic hazards to fishery productions by meteorological forecasting. Better security through the reduction of shipwrecks.

– Better productivity and reduced risk of aquaculture production disasters through information about ocean condition and water quality (e.g. red tide).

Management of fishery resources, securing safe operations, and detection of suspicious vessels by tracking locations and operations of vessels with verified position authentication.

• Forestry

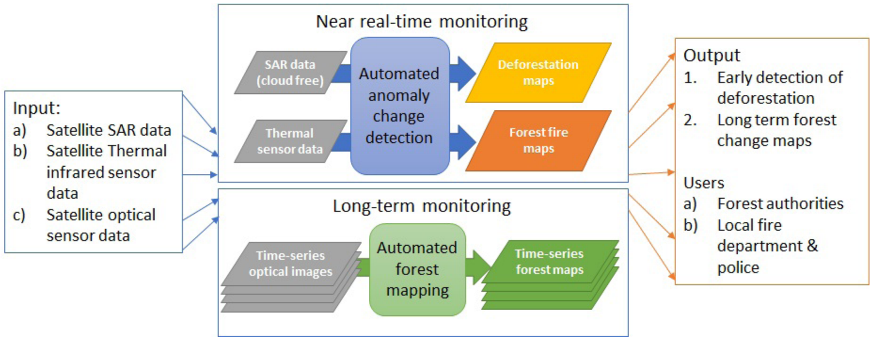
By measuring forest resources such as biomass and its distribution through SGT, the optimisation of timber production could be achieved, including logging, transport, and processing.

– Ensure sustainable use of forest resources (planting, conservation, logging) by continuous monitoring of forest resources (biomass and tree types).

– Better efficiency and effectiveness in logging, lumber, and transport by quantified planning of forestry operations. Less labour hazard.

– Suppress damage of forest fires and illegal loggings.

Figure 14: Forest Monitoring with SGT



SAR = synthetic aperture radar, SGT = space and geospatial technology.

Source: Authors.

• Construction

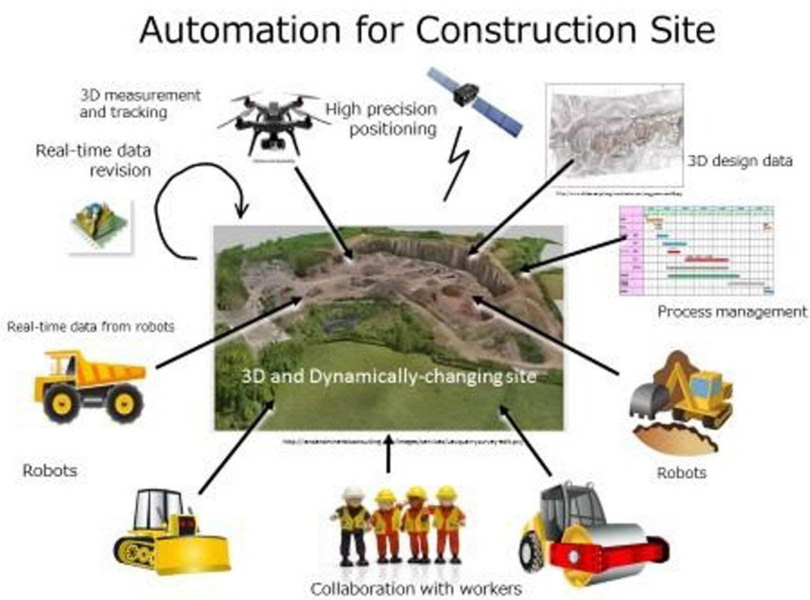
SGT will accelerate the automation of construction works through very precise real-time positioning, 3D mapping, and monitoring of environmental impacts of the works. In parallel, the process of construction will be fully digitised, which will accelerate the improvement of the construction management and technology.

– Risk reduction through effective designs and construction plans with accurately measured and shared data on terrain and geology.

– Effective management of labour and staff safety with better efficiency in transport and stock usage through continuous and accurate monitoring of things and people's position.

– Quality assurance and improvement through detection and prevention of faults by accurate 3D measurement of construction progress.

Figure 15: Automation in Construction Industries with SGT



3D = three dimensional, SGT = space and geospatial technology.

Source: Authors.

• Manufacturing

– Lower logistics cost and uncertainty to deliver and procure products, leading to cost reduction of manufacturing.

• Service

– Less cost of service delivery through significant reduction of cost and uncertainty in logistics.

– Realise possibilities of micro-consumer services, such as e-commerce and food delivery, through low-cost and effective delivery services.

– Better reliability of mobile payment using personal credit information based on locations and activities verified by positioning authentication.

– Scaling up of mobile micro consumer services through more reliable personal micropayment systems.

Figure 16: SGT to Support Distribution and Service Sectors

ID = identification, SGT = space and geospatial technology.

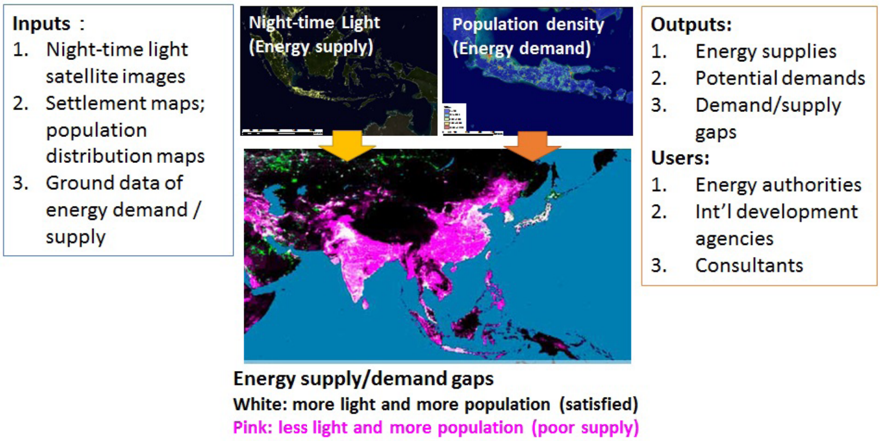
Source: Authors.

• Energy sector

–Energy (electricity power) supply with renewable resources, typically wind, water, and solar radiation, could be estimated with SGT, leading to smoother matching of energy supply and demand; while energy demand could be estimated by combining multi data sources like people activity and movement monitoring, heat radiation measurement from buildings/houses and city lights mainly from airborne and satellite observation.

Figure 17 is a visualisation of energy demand and supply gaps through satellite observations of city lights.

Figure 17: Estimating Energy Needs through Night Satellite Observation



Source: Authors.

Support Environmental Resources Management

Natural or environmental resource management is an area where SGT could make significant contributions because the lack of information on the status of and changes in resources has created difficulties in decision-making and evaluation of actions taken. In addition, through the improvement of efficiency in social systems like transportation/logistics, achieved with the help of SGT, GHG emissions and impacts on the environment can be reduced.

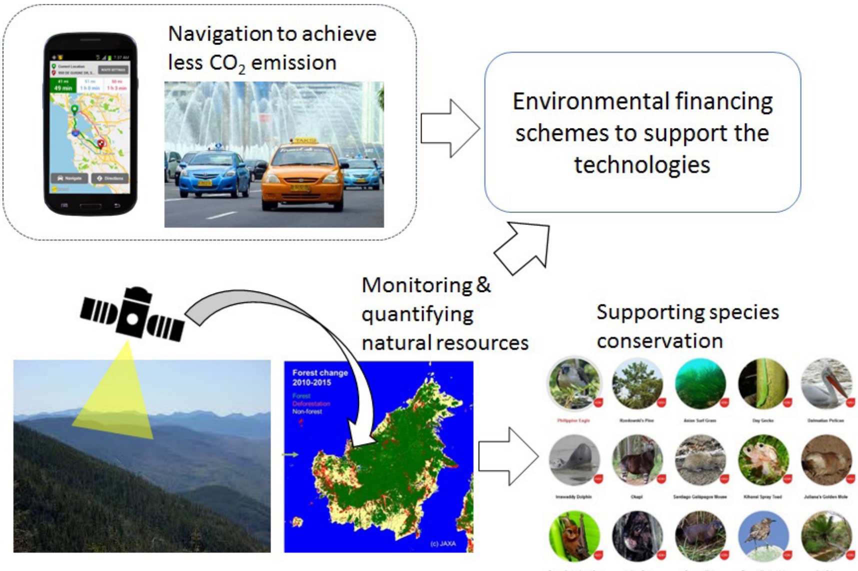
• Carbon dioxide (CO2) emission reduction by optimising transport operations (taxi, commercial vehicles, and shipping vehicles) based on vehicle mobility data. This supports fundraising by environmental finance schemes such as bilateral carbon offsets.

• Effective conservation of ecosystem services by continuous monitoring of the ecological status of forests, oceans, and marines.

• Social bonds can be applied to improve and sustain the services based on the value evaluation of ecosystem services.

• Effective conservation and management of specific areas for species conservation and gene banks.

Figure 18: SGT for Environmental Resouces Management



CO2 = carbon dioxide, SGT = space and geospatial technology.

Source: Authors.

Strengthen National Land and Sea Management

Enhancing observation capabilities for better informed decision-making enabled through SGT can contribute to the strengthening of the management of land and sea territories.

• Higher accuracy of forecasts in ground/ocean weather information using advanced satellite earth observation. This provides basic background information to a broad range of industries and people in making decisions from daily actions to long-term investments.

• Achieve marine safety and fishery resources conservation by strengthening detection and monitoring of unidentified ships.

• Better safety/security of people by improving accuracy of monitoring and forecasting floods, slope failure, earthquakes, and volcanic eruptions.

Policy and Economic Impact

The policy directions of the ASEAN, incorporated in 'ASEAN Connectivity 2025', are illustrated in Figure 22. The contributions and impacts of SGT on the policy directions above are summarised in Table 2.

Figure 19: ASEAN Connectivity 2025

ASEAN = Association of Southeast Asian Nations.

Source: ASEAN Secretariat.

The impacts and contributions of SGT were summarised in the previous section. However, the economic impacts of SGT cannot be evaluated quantitatively because SGT is an emerging technological system and no enough historical data is available to delineate the impacts.

Table 2: Contributions and Impacts of SGT on Policy Directions

Contribution to ASEAN Strategic Connectivity	Sustainable Infrastructure	Data Innovation	Seamless Logistics	Regulatory Excellence	People Mobility
Real-time localisation and tracking of people, cargoes, and vehicles (air, sea, and land)	Efficient planning/ designing and smarter operation	Creation of new services for SMEs	Supply chain efficiency through addressing key checkpoints	Consolidated data policy balancing openness and security	Better risk management (accidents, epidemics, disasters etc.)
Real-time monitoring of environmental and contextual information covering all land and sea	Real-time monitoring of infrastructure and uses	Creation of new services for SMEs	Enhanced trade routes and logistics	Open data policy and standards for distribution	Better risk management
'Ubiquitous' data communication at any time/ anywhere	Real-time monitoring and remote management for all territory	Enhance borderless data network	Real-time monitoring of cargo	Regulations for safer, reliable communication	Mobility support, risk alert service
High-precision mapping of 3D space and landscape framing activities of people and autonomous vehicles/ machines	Real-time monitoring and proactive maintenance	Facilitating automation in indoor to outdoor environment	Automated logistics with autonomous truck and logistics robots	Quality assurance and secure positioning	Seamless navigation from indoor to outdoor

3D = three dimensional, ASEAN = Association of Southeast Asian Nations, SGT = space and geospatial technology, SMEs = small and medium enterprises.

Source: Authors.

Conceptually, the economic benefits of SGT could be categorised as follows:

1. Cost reduction and efficiency improvements in existing industries and services.

Monetary evaluation could be made if the contribution of SGT could be delineated from the entire cost reduction.

2. Emergence of new services and industries.

It also includes the expansion of employment and contribution to new market development.

3. Improvement of people's welfare such as safety, stability of community/ society, and quality of life.

The improvement can be evaluated in terms of social indicators such as the number of casualties by traffic accidents. Monetary evaluation, however, is not easy. When benefit is localised or belongs to a specific area/location, land price, or rent could be used for evaluation using a more subjective approach.

4. Environmental impacts or benefits such as the reduction of GHG emission, ecosystem conservation, and biodiversity.

As far as carbon emission is concerned, reduction of emission could be evaluated in monetary terms. Conservation of ecosystems and biodiversity etc. could be evaluated in terms of indicator value changes, such as the number of species.

Though SGT is not yet deployed on a full scale, some elementary technologies are applied to some fields such as traffic management (traffic monitoring and navigation, guidance, etc.) in developed countries.

According to the report of the Ministry of Land, Infrastructure and Tourism (MLIT) of Japan, the introduction of the Electronic Toll Gate (ETG) to national highway systems, assuming 50% of cars use ETG, is estimated to have a cost reduction of ¥350 billion per year (US$3.2 billion)[1]. Since the total loss due to traffic congestion is estimated to be ¥12 trillion per year (US$110 billion) or 2.4% of gross domestic product (GDP)[2], 3% of the congestion cost was reduced by the introduction of ETG.

To approximately evaluate the order of possible SGT contribution in mitigating the severity of social issues, the authors summarised loss or damage due to such social issues as traffic congestion and safety. It should be noted, however, that these examples are not peer-reviewed reports on the losses but collected from

1 2006, http://www.mlit.go.jp/road/ir/ir-perform/h18/09.pdf
2 2006, http://www.mlit.go.jp/road/ir/ir-perform/h18/07.pdf

governmental reports, newspapers, and other sources to highlight the magnitude of the loss.

1. Traffic congestion

According to the Jakarta Post,[3] US$5 billion is lost each year due to traffic jams. This means US$167 loss per person per year or 5% of the per capita GDP. Thailand Herald reported in 2016 that traffic jams in Bangkok cost the economy ฿11 billion.[4]

2. Disaster loss

The economic damage of the tsunami caused by the 2004 Indian Ocean Earthquake to Thailand was evaluated by the Natural Resources and Environment Program, Thailand Development Research Institute.[5] According to the report, total loss was ฿40.6 billion (฿12.2 billion for human loss and ฿28.4 billion for capital loss), around 0.3% of Thailand's GDP.

3. Traffic accidents

The Bureau of Highway Safety, Department of Highways of Thailand reported that the annual economic loss of traffic accidents as of 2004[6] is estimated to be US$5,630 million (including human loss of US$3,175 million), equivalent to 2.6% of GDP.

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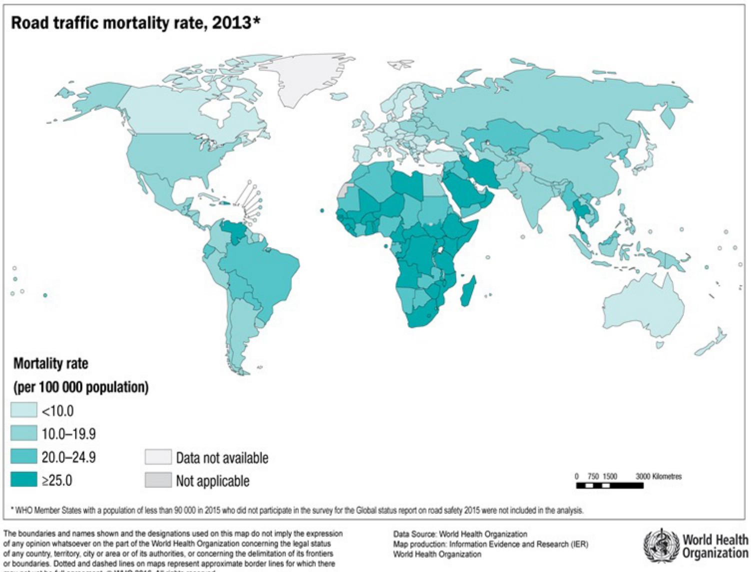
[3] http://www.thejakartapost.com/news/2017/10/06/jakarta-foots-us5b-annual-bill-for-traffic-jams-minister.html

[4] http://www.thailandherald.com/news/247551269/cost-of-traffic-jams-in-bangkok-costs-the-economy-11-billion-baht

[5] http://tdri.or.th/wp-content/uploads/2013/01/n75.pdf

[6] http://bhs.doh.go.th/files/Project/accident/ENG/Executive%20Summary_EN

Figure 20: Road Traffic Mortality Rate 2013



Source: World Health Organization.

4. Logistics

The logistics performance of ASEAN countries is shown in Table 3, based on the Logistic Performance Indicator of the World Bank.[7] Logistics cost seems to be affected by the size of the territory and the level of transportation infrastructure. The performance improvement of the logistics industry plays a very vital role in economic growth.

[7] Logistics Performance Index of ASEAN Countries

Table 3: Logistics Performance Index of ASEAN Countries

Country	**Logistics performance index** Overall (1=low to 5=high)	**Logistics** (% of 2015 GDP)	**2015 Logistics Cost**
Brunei Darussalam	2.87	–	–
Cambodia	2.8	–	–
Indonesia	2.98	24	206.7
Lao PDR	2.06	–	–
Malaysia	3.42	13	38.5
Myanmar	2.46	–	–
Philippines	2.86	13	38
Singapore	4.14	8.5	25.2
Thailand	3.26	15	59.9
Viet Nam	2.98	20	38.3

ASEAN = Association of Southeast Asian Nations, GDP = gross domestic product, Lao PDR = Lao People's Democratic Republic.

Source: Logistic Performance Index, World Bank, 2015.

CHAPTER 3

Implications for ASEAN Policies of Better Integration and Connectivity

The previous chapters emphasised the benefits of spatial and geospatial technology (SGT) for the Association of Southeast Asian Nations (ASEAN), focusing on issues in a wide range of areas such as logistics, disaster management, and public health. This chapter adopts another perspective by looking at the implications for ASEAN policies of the enhancement of ASEAN connectivity through SGT.

This chapter is organised as follows:

1. What can be achieved with coordinated ASEAN policies?
2. ASEAN policies on physical infrastructure.
3. ASEAN policy directions on sustainable value creation from data.

What can be Achieved with Coordinated ASEAN Policies?

To benefit from the full potential of SGT, ASEAN countries will need to adopt coordinated policies aimed at establishing both a strong infrastructure supporting the use of SGT and a legal framework to organise SGT data utilisation.

1. Physical infrastructure:
    - Space systems: observation, positioning, and communication; and
    - Ground-based systems: base station networks, satellite communication points, and ground data networks.

2. Data policies and associated public/industrial policies:
   - Sustainable value creation from data by respecting the rights and concerns of data producers and associated stakeholders;
   - Separation of data holdings/ownership and advanced usage by value creators/producers; and
   - Sharing benefits amongst data producers and value creators.

The next two sections further develop these necessary political goals.

ASEAN Policies for Physical Infrastructure

While it has immense potential benefits for the region, the utilisation of SGT requires important initial investments for the establishment of highly advanced technological infrastructures, both in outer space and at ground level.

Space systems: observation, positioning, and communication

Earth observation

Concerning the use of earth observation technologies, the authors recommend different approaches, depending on the kind of application requested.

1. In the case of global earth observation, the cost of establishing a large constellation of expensive satellites would be too high for ASEAN countries, even if they were united behind this goal. Therefore, it would be beneficial for ASEAN to join global earth observation open data clubs such as the Group on Earth Observations.
2. In the case of local observation, ASEAN countries could develop indigenous capabilities through the establishment of regional policies, balancing competition and collaboration. We recommend two approaches that can be pursued in parallel:
   (a) ASEAN satellites. Joint development/operation of ASEAN satellites by member countries under the banner of ASEAN. We could even imagine the establishment of an ASEAN satellite constellation.
   (b) National satellites. Individual development of satellites by member countries, eventually participating in an ASEAN constellation.

Two further comments can be made regarding the development of local observation capabilities:

1. There has been a strong focus on the importance of the establishment of an ASEAN constellation. Facing the same challenges on a relatively similar environment and having SGT as a solution, transcending national boundaries, it would be highly inefficient for ASEAN member countries to develop in parallel similar technologies without collaborating. Moreover, beyond simple data sharing, the coordinated operation of various ASEAN satellites would improve the efficiency of SGT by allowing an increase in covered area and/or revisiting the frequency of the satellites.
2. Beyond regional utilisation, the data produced by ASEAN satellites could then be shared in a previously mentioned global earth observation open data club.

Satellite positioning systems

The ongoing Global Navigation Satellite Systems (GNSS) operations are operated by independent bodies, though the operations have potentials to collaborate for better services supported by high-precision and real-time positioning technologies. It is useful to design such collaborative systems by i) space segment, ii) control segment, and iii) user segment.

-Space segment

The space segment covers designs operations of satellites, such as structuring constellation satellites. As well as its usefulness for earth observation, regional cooperation in satellite operations will be beneficial to participating countries through infrastructure sharing. Currently, the Asia and Pacific region has more intensive GNSS coverage than other regions owing to the global positioning system (GPS); GLONASS; Galileo; Compass; the Indian Regional Navigation Satellite System or IRNSS; and the Quasi–Zenith Satellite System (QZSS). QZSS is a GNSS constellation dedicated to East Asia, Southeast Asia, and Oceania, with its orbits focusing on these areas. International cooperation of QZSS applications could be expected to be a model promoting regional positioning satellite systems.

-Control segments

Control segments include infrastructure to observe movements of satellites and the computing orbit data (ephemeris), and monitor the satellite clock and compute their correction parameters, which are the bases of high-precision positioning techniques such as Real Time Kinematic (RTK) and Precise Point Positioning (PPPo). MADOCA high-precision positioning is realised by data management and processing of signals from space and delivery of processed data to user segments. The Continuous Operational Reference Station (CORS) can be included in the control segment because of its position as a ground infrastructure, though it could also be part of the user segment as it comprises user segment technologies.

While PPPo does not need cooperation amongst operational bodies because of its independence from ground reference points, RTK needs cooperation amongst operational bodies as the positioning accuracy of RTK is affected by its proximity to reference stations. The integration of the reference stations infrastructures, especially the CORS network, should be beneficial for GNSS user segments to provide high-precision positioning data to applications. There are two key issues regarding the regional integration of the CORS infrastructure.

Intra-country cooperation – It is sometimes challenging to integrate CORS networks even within a country because CORS operation bodies spread from the public sector to the private sector, where data policy varies widely. International cooperation requires dialogues with each operating body, unless single-window mechanisms are established. For example, in Thailand, the public CORS operating bodies are the Royal Thai Survey Department, Hydro and Agro Informatics Institute, Department of Land, Geo-Informatics and Space Technology Development Agency (GISTDA), Department of Public Works, and Town and Country Planning. An international mission had to construct agreements with each agency to use their CORS infrastructure. Recently, the Government of Thailand has concluded a single-window policy of international cooperation on the use of the CORS network in Thailand, with the Royal Thai Survey Department taking responsibility for the coordination of international cooperation amongst operating agencies. Thailand will be a good model for better integration of CORS networks within ASEAN countries.

Inter-country cooperation – The CORS networks sometimes contribute to high-precision positioning beyond borders, especially for border areas with little density of reference stations. Data transfer beyond borders is another challenging issue because CORS data contain sensitive military information. Developing agreements will be initiated by specific applications with tangible benefits favourable to political considerations. When a certain number of agreements has been concluded, ASEAN may recommend that states develop a multilateral agreement on the use of CORS networks amongst ASEAN states.

-User segment

In the past, RTK–GPS instruments had been mainly for professional surveys and cost tens of thousands of dollars. Only hand-held GPS devices were affordable to consumers. However, in the last few years, low-cost RTK devices have become available at cheaper prices. In addition, more smart phone penetrations reach high-precision positioning service due to the hybrid positioning using GNSS and cell tower-based positioning. Although such consumer market trends and growth are fairly independent from governments' policies, the ASEAN policy will include such conditions and projections.

Satellite communications

While satellite communications are regarded as a key technology for Internet of Things (IoT) applications, operation costs are high for ASEAN states. Store and forward is a technique to reduce costs of satellite communications, in which a satellite receives data from a ground transmitter when at its vertical, stores the data on the satellite, and transmits the data to a ground receiver when at the vertical of the ground receiver. Store and forward reduces communication costs at the expense of a lower update frequency. The store and forward technique is expected to interconnect sensor networks in areas without landline Internet connections, such as remote areas and oceans. The technology could support ASEAN states in the continuous monitoring of the environment and disasters in a sustainable way through low-cost advantage.

Ground-based systems

The second type of infrastructure that will need to be promoted through ASEAN policies is ground systems. The authors recommend the development of three categories of ground systems.

1. Base station networks. National development of base stations. This is necessary to downlink data produced by observation satellites or gathered by communication satellites from ground measurement stations to form international networks. By having a large network of interconnected base stations, real-time data exchange will be available to ASEAN countries; however it would require an absolute interoperability of all base stations.
2. Satellite communication points. Individual development with interoperability.
3. Ground data networks. Individual development of ground measurements stations, emitting in-situ data towards ASEAN communication satellites. The adoption of common data standards will be necessary for the functioning of the full system.

The key word here is interoperability. Contrary to satellites that move in outer space, which is a neutral area for international law, ground stations will be placed on the exclusive territories of ASEAN Member States. Therefore, to use the potential of such a wide network, it is necessary to ensure the compatibility between all infrastructures and to facilitate the adoption of common standards throughout ASEAN.

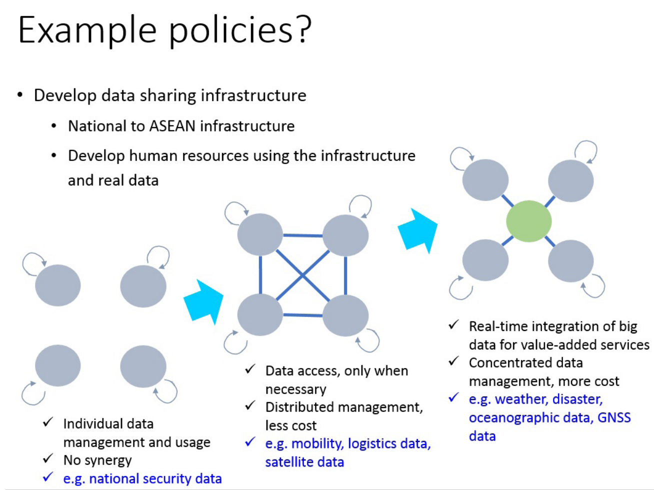
ASEAN Policy Directions for Sustainable Value Creation from Data

This section aims to answer the following question: How to sustain value creation from data while respecting the rights and concerns of data producers and associated stakeholders?

To answer this question, the authors recommend that specific policy directions, consisting of the adoption of coordinated data policy for advanced usage, be followed. Focus should be placed on:

1. Separating data holdings/ownership and advanced data usage, and integration by value creators, as well as respecting the rights and concerns of data producers/stakeholders. In other words, ensuring a smoother flow of data and a clearer responsibility for data usage.
2. Sharing the benefits of value creation from data amongst data producers and value creators.
3. Monitoring and assessing the risks and benefits of data usage and data market competition/concentration in a coherent manner.
4. Accelerating human resource development for value creation.

Figure 21: Example Policies



ASEAN = Association of Southeast Asian Nations, GNSS = global navigation satellite systems.

CHAPTER 4

Roadmap for Connectivity Enhancement and Flagship Projects

Based on all the issues presented and the solutions proposed in the previous chapters, this chapter summarises the key development areas for the enhancement of connectivity and resilience in the Association of Southeast Asian Nations (ASEAN). Since ASEAN countries are divided into two categories, insular and continental, it is necessary to consider their relative specificities.

Therefore, this chapter differentiates between land connectivity and ocean connectivity, and proposes recommendations aiming at their enhancement. For each of them, after stating precise targets, the authors recommend specific actions that should be carried out to achieve those targets.

Better Land Connectivity

More than half of ASEAN countries – Cambodia, Lao People's Democratic Republic (Lao PDR), Malaysia (partially), Myanmar, Singapore, Thailand, and Viet Nam – are continental. Therefore, enhancing land connectivity must be a great priority for ASEAN.

Figure 22: Improved Land Connectivity with SGT

ASEAN = Association of Southeast Asian Nations, GNSS = global navigation satellite systems
SGT = space and geospatial technology.
Source: Authors.

Targets

1. Smoother and safer transport, logistics, and people flow
• Drastic cost reduction and accident reduction for mobility

2. Better and secure management of transportation (e.g. road pricing, cargo management, people mobility management)
• Better security and management, reduction of greenhouse gases (GHGs)

3. Accelerating implementation of autonomous vehicles, automation in transport, logistics, construction, agriculture/forestry, etc.
• Advanced/leading technologies and implementation

4. Providing advanced positioning services for safer mobility
• World-first services for safer and more secure mobility

Actions

1. Develop incubation centres of advanced positioning services and applications
(a) High precision, authentication (anti-spoofing)
(b) Support industrial development and business creation
(c) Model case: Global Navigation Satellite Systems (GNSS) incubation centre, Geo-Informatics and Space Technology Development Agency (GISTDA), Thailand

2. Establish connected networks of GNSS base stations
(a) Common location basis of ASEAN for better consistency and accuracy
(b) High-precision mapping, autonomous vehicles (logistics, public transport) and machines (logistics, agriculture, construction, etc.), crust monitoring
(c) Enhancing the National Spatial Data Infrastructure (NSDI) for better geospatial data dissemination and integration

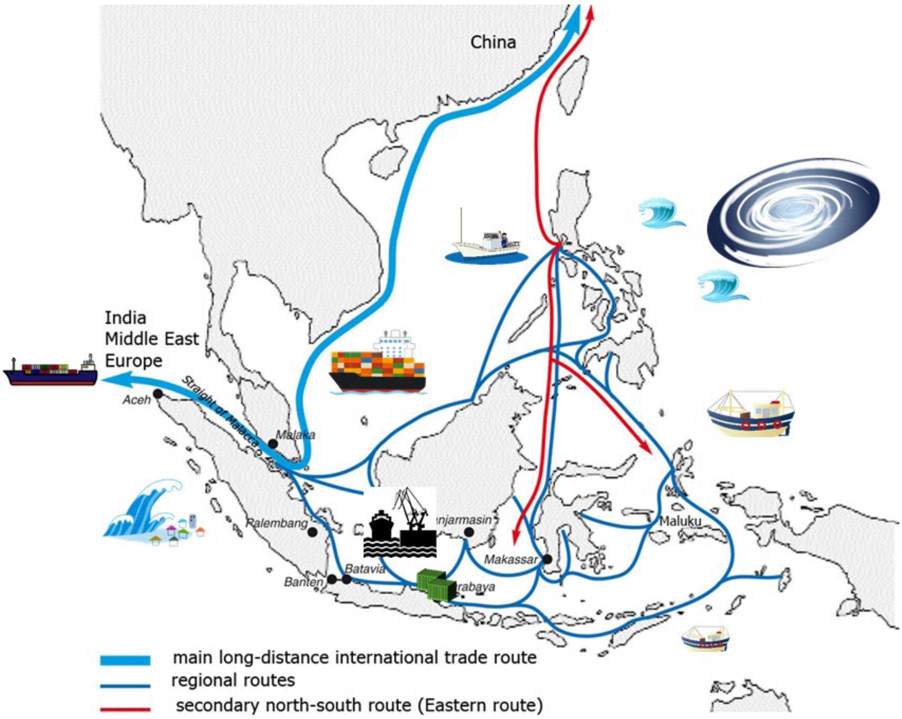
3. Provide world-first advanced positioning services
(a) Free high-precision authentication service with Quasi–Zenith Satellite System (QZSS)
(b) Accelerate social implementation: road pricing, illegal vehicle detection, and secure logistics

4. Develop data sharing infrastructure and human resource development facility
(a) Logistics, transportation, people flow, autonomous vehicles, etc.
(b) Incubation of data experts serving better data usage and management

Better Sea Connectivity

Four ASEAN countries are either fully or partially insular. These are: Brunei Darussalam, Indonesia, Malaysia (partially), and the Philippines. Indonesia is one of the leading Asian economies. Moreover, except for Lao PDR, all ASEAN countries have access to the sea, prompting the improvement of sea connectivity.

Figure 23: Improved Sea Connectivity with SGT



SGT = space and geospatial technology.

Source: Authors

Targets

1.Smoother and safer transport and logistics in the seas
2.Reduction of cost/time and marine incidents
3.Safer and more secure industrial activities in the seas
4.Accident reduction and better control of sea activities
5.Sustainable management and development of natural resources
6.Control of natural resource development and conservation of ecosystems

Actions

1. Develop a marine weather forecast and application centre
(a) More accurate and integrated marine weather monitoring and forecasting
i. Numerical models, data assimilation, and satellite data like Himawari
(b) Provide marine data for marine industrial activities such as fishery and aquaculture

(c) Incubate advanced applications for fishery, aquaculture, and environmental management
(d) Model case: Institute for Marine Research and Observation IMRO (Indonesia)
2. Expand world-first advanced positioning services
(a) Free and precise authentication service with QZSS in the seas and ocean
(b) Accelerate social implementation: monitoring and control of fishery, detecting unidentified ships, secure marine logistics, automation of cargo handling etc.
3. Develop data sharing infrastructure and human resource development facility
(a) Marine and land weather, marine logistics, transportation, etc.
(b) Integration of space data and in-situ data
(c) Incubation of data experts serving better data usage and management

Flagship Projects for the Development of Data Sharing Infrastructure and Related Human Resources

To demonstrate the efficiency of SGT in the enhancement of ASEAN connectivity, the authors present potential flagship projects as well as implementing agencies.
Beyond the development of data sharing space infrastructure (satellite and ground systems), these projects aim to:
1. Promote human resource development for advanced data analysis and usage, including artificial intelligence and the Internet of Things (IoT) technologies.
2. Demonstrate best practices of data sharing and integration

Concretely, the proposed flagship projects focus on:
1. Land applications focusing on positioning services, implemented by the GNSS Innovation Center of GISTDA, Thailand
2. Marine applications driven by IMRO of Indonesia
3. Disaster response and risk management, supervised by the ASEAN Coordinating Centre for Humanitarian Assistance on Disaster Management (AHA Centre) in Jakarta, Indonesia
4. National Space Data Infrastructure and geospatial application centres in each member country.

CHAPTER 5

Conclusions

The rise of SGT has had a deep impact on all layers of society. By combining a highly technological space infrastructure (earth observation, positioning, and communication) with new technologies for data utilisation (artificial intelligence, IoT, etc.), the contribution of SGT to the economy is already visible but should be further promoted (1.1.1).

More specifically, SGT could participate in the realisation of the 2025 ASEAN vision of increased resiliency and connectivity. In 2016, the Master Plan on ASEAN Connectivity 2025 reaffirmed the importance of space technologies and data sharing for regional economic development (1.2.2). As explained previously in this report, SGT can play a prominent role in the global optimisation of the ASEAN production system (1.3.2) and the transformation of the economy with the third unbundling (1.3.3). SGT will also help ASEAN develop an ambitious vision towards the status of Data-Driven Innovation Economy 2.0.

It is therefore primordial for ASEAN member countries to develop a common vision and common policies towards the establishment of an efficient physical infrastructure for data collection in ASEAN (3.2). It will also be necessary to create a regional data policy for data utilisation and data format standardisation (3.3).

Finally, several ambitious flagship projects should be implemented to increase both land (4.1) and sea connectivity (4.2), and to continuously develop human resources with adaptive systems (4.3). It will support the promotion, maintenance, and enhancement of the awareness of 'We' and the deepening of the ASEAN identity.

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Contributions from the Association of Southeast Asian Nations (ASEAN) partners

After the project wrap-up workshop in Jakarta, participants were asked to provide an abstract summarising the prominent challenges and solutions in their home countries. It encompasses various issues such as remote sensing and disaster risk reduction.

The abstracts presented below are sorted by alphabetical order of the countries.

Indonesia (1/2)

The use of satellite data for identifying potential fishing grounds in Indonesia's Seas

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High-quality data on the marine environment plays a vital role in resources management. Indonesia, with large marine areas, needs to be managed properly to support sustainable use of marine and coastal resources. The demand for the use of low-cost satellite data for operational fisheries oceanography in Indonesia's Seas is high. Several studies on the use of satellite data have shown valuable results for fisheries management. Various satellite remote sensing data have provided real data that can be used to monitor marine resources. The command uses satellite data including those from Aqua's and Terra's moderate-resolution imaging spectroradiometer (MODIS), GeoEye's OrbView-2's Sea-Viewing Wide Field-of-View Sensor (SeaWiFs), Terra's Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER), Landsat, and the National Oceanic and Atmospheric Administration. This paper gives an overview of the application of remote satellite sensed data for identifying potential fishing grounds (PFGs) around Indonesia's Seas. Remotely sensed data are used as primary data to analyse PFG maps such as sea surface temperature, sea surface chlorophyll-a, front, and photosynthetically available radiation (PAR) data. The PFG maps were semi-automatically processed, combining computer and human processes. The PFG maps have three products – national PFG, harbour PFG, and specific area PFG. The PFG maps were distributed routinely through several sources: website, facsimile, and mobile applications (NELPIN = nelayan pintar). The PFG maps were validated by using several approaches, such as research activities, feedback from local governments/users, overlay fishing vessels from radar detection, and overlay Visible Infrared Imaging Radiometer Suite (VIIRS) data. Using radar technology (for identification of fishing vessels), we were able to validate the PFG maps. For example, in this paper, we attempted to analyse and overlay the PFG maps and the distribution of fishing vessels in Natuna Sea (Fisheries Management Area/FMA-711). We found that the accuracy of the PFG maps varied, with an average accuracy of about 40%. In addition, we also conducted validation using VIIRS (night time images) data. This application showed that low-cost satellite data has become an ideal tool for identifying potential fishing grounds. These results show that the enhancement of PFG maps still needs to be considered to support operational fisheries. Enhancing PFG maps through automatic systems and increasing their accuracy are highly required.

Keywords: satellite data, fisheries oceanography, potential fishing ground, Indonesia's Seas.

Indonesia (2/2)

Satellite Remote Sensing Application for Economic Development in Indonesia

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Why is remote sensing necessary in Indonesia? Indonesia is a large country with 1,879,183 km2 of land and 3,544,743 km2 of ocean. Without remote sensing, Indonesia will have difficulties monitoring the country. Indonesia abides by Space Act No. 21/2013, which mandates the Lembaga Penerbangan dan Antariksa Nasional (LAPAN) to provide remote sensing data with minimum cloud coverage and provides the standard methodology for remote sensing data processing and analysis. For these reasons, LAPAN developed three ground stations to receive remote sensing data. They are in Parepare (South Sulawesi), Rumpin (West Java), and Pekayon (Jakarta). These three ground stations can cover all of Indonesia and receive low-resolution data (Terra/Aqua MODIS, NOAA, Suomi NPP, and Himawari-8), medium-resolution data (Landsat-7 and Landsat-8), and high-resolution data (SPOT 6/7). These data are free for government institutions. Other data provided by LAPAN are very high-resolution data such as Pleiades, Quickbird, Worldview, and some synthetic aperture radar (SAR) imageries. To further service users, LAPAN also provides cloud-free mosaic data of Landsat-8. It is now available from 1999 to 2016. It is useful for land use mapping with a maximum scale of 1: 100,000. It is also useful for forest change and degradation.

How does this affect economic development? What applications have been used in Indonesia? Remote sensing technology has been applied in many sectors, but it can be divided into five categories: (1) land resources, (2) coastal and marine resources, (3) environment, (4) disaster mitigation, and (5) other strategic applications. Agriculture, forestry, mining, regional planning, and water resources are in the land resources category. PFGs, mangroves, coral reefs, and water quality are in the coastal and marine resources. Hazardous waste, deforestations, land use changes, and oil spills are in the environment categories. Floods, landslides, volcano eruptions, forest fires, and drought detection and monitoring are in the disaster mitigation category. Tax, drag planting, and security assessments are in the other strategic applications. All those applications have been done in the remote sensing applications centre of LAPAN. In relation to economic development in Indonesia, LAPAN provides the remote sensing data and many applications to support economic development. There are several applications that have been done that support the ministries. The monitoring of paddy growth every 8 days can be used in estimating paddy production, in deciding to import rice from other countries, and in deciding fertiliser and farmer machine distributions. PFGs can be used to increase fish catch numbers of and the efficiency of oil. Remote sensing can also be used to increase the taxes to be paid by taxpayers, especially for plantations, mining, and forestry companies. These applications must be improved in other provinces to increase the tax payments. Another application that can support economic development is the identification of mining areas. It can help the government or mining company identify the location of mining areas. It will increase the number of mining exploitation and increase the country's income.

The next question is, 'What are the challenges?' and 'How do we convince users?' This paper answers these two questions. The first challenge is convincing users. To convince the user, the remote sensing application should be accurate and up-to-date. Accuracy can be assured through good research and up-to-date information can be provided through high-temporal-resolution of remote sensing data and automatic image processing. Research collaborations with users are necessary to meet the requirements of users. LAPAN has collaborations with many government institutions, local governments, private companies, and foreign institutions. This will deal with the first challenge. The second challenge is the human resources. Increasing the capacity of human resources is needed, not only in terms of quality but also quantity. The number of people who deal with remote sensing activities is quite low. To tackle this challenge, LAPAN has a programme on technical training for local governments to increase the capacity and the number of people with remote sensing skills. The last challenge concerns the independence of the technology. At present, almost all remote sensing data come from other countries. Indonesia does not own a remote sensing satellite and its development is necessary.

Keywords: remote sensing, economic development, challenge, technology independence.

Lao People's Democratic Republic

National Policy on Disaster Management and Climate Change

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Lao People's Democratic Republic (Lao PDR) is very vulnerable to the climate. Its contribution to global greenhouse (GHG) emissions was only 51,000 Gg or 0.001% of total global emissions. Despite this, Lao PDR has ambitious plans to reduce its GHG emissions while at the same time increase its resilience to the negative impacts of climate change. The country is also experiencing increasingly frequent episodes of drought. Severe drought occurred in 1996, 1998, and 2003. It is estimated that 6 out of 17 provinces are already at high risk of drought. Droughts adversely affect water resources, hydroelectricity generation, and agricultural production, resulting in widespread economic losses.
The Natural Resources and Environment Sector Working Group (NRE SWG) was established by the government under Government Notice No. 773 dated 10 November 2011 as part of the Round Table Meeting.

The Environment and Climate Change Sub-Sector Working Group and the Disaster Division under the Water Sub-sector Working Group were merged and will be working as one group under the name: Disaster, Climate Change, and Environment Sub-sector Working Group (DCCESSWG). DCCESSWG consists of four departments and one institute – (i) Department of Disaster Management and Climate Change (DDMCC); (ii) Department of Environmental Quality Promotion (DEQP); (iii) Department of Pollution Control (DPC); (iv) Department of Environmental and Social Impact Assessment (ESIA); and (v) Natural Resources and Environment Research Institute (NREI).

The objective of the working group is mainly to support the Ministry of Natural Resources and Environment (MONRE) in the implementation of the following:

- The MONRE 10-Year Strategy (2016–2025) and the 5-Year Plan (2016–2020), particularly Action No. 5 on environment, climate change, and disaster. The 5-year action plan sets the direction for implementing MONRE's first Natural Resources and Environment Strategy (2016–2025), with the overall goal of 'making Lao PDR green, clean and beautiful, based on green economic growth, to ensure sustainable resilient development and climate change'.

- The Eighth National Economic and Social Development Plan (8th NESDP) for 2016–2020, in particular outcome 3, output 1 – environmental protection and sustainable natural resources management; and output 2 – preparedness for natural disasters and risk mitigation. The long-term direction of the natural resources and environment sector focuses on five key themes: (i) sustainable management and planning of the use of natural resources and environment, (ii) sustainable environment planning for city and rural development; (iii) strengthening the capacity of Lao PDR on climate change adaptation and mitigation; (iv) enhancing regional and international integration; and (v) building MONRE's institutional capacity effectively, efficiently, and sustainably.
- Sustainable Development Goals (SDGs) focusing on the issues and topics (themes) related the environment, climate change, and disaster (SDG 11: Make cities and human settlements inclusive, safe, resilient, and sustainable; SDG 13: Take urgent action to combat climate change and its impact; SDG 14: Conserve and sustainably use the oceans, seas, and marine resources for sustainable development; and SDG17: Strengthen the means of implementation and revitalise the global partnership for sustainable development).

Lao PDR's Policy Instrument for Disaster Management and Climate Change

1. The law on Disaster Risk Management and Climate Change (to be considered for approval at the end of 2018). We have completed consultation on the current draft with eight northern provinces.
2. The integration of climate change and disaster preparedness into the Environment Protection Law (2012 revised version) and the 8th National Social-Economic Development Plan.
3. The National Adaptation Programme of Action, which was approved in 2009. The National Adaptation Programme of Action (2009) maps out a country-driven programme to address immediate and projected climate change adaptation requirements in agriculture, forestry, water

resources, and public health sectors. The adaptation programme was further developed by the National Strategy on Climate Change (NSCC) to cover the main sectors of the economy – agriculture, forestry and land use change, water, transport and energy, urban development, industry, and public health sectors.

4. The First and Second National Communication on Climate Change (approved in 2000 and 2013 respectively). Lao PDR is preparing for the 3rd National Consultation like other countries.
5. The National Strategy on Climate Change, which was approved in 2010.
6. The Climate Change Action Plan 2013–2020, which was approved in 2013. The action plan has four main key initiatives – (i) Strengthening institutional resource capacity on climate change, including organisational arrangements; technical capacity; national focal point; technical working group on climate change; and climate finance – fiscal system; management of international assistance; participation in carbon/climate finance; (ii) Enhancing the capacity for adaptation; (iii) Enhancing the capacity for mitigation; and (iv) Strengthening education and public awareness.
7. The Guidelines on the Development and Consideration of the Proposed Clean Development Mechanism (CDM) Project in Lao PDR, which was approved in 2012.
8. The signed bilateral document with Japan to launch the Joint Crediting Mechanism, approved in 2013.
9. The Guideline on ecosystem-based adaptation (EbA), which was approved in 2014.
10. The National Intended Determined Contribution (INDC) of Lao PDR to the United Nations Framework Convention on Climate Change (UNFCCC) on 1 October 2015. This INDC has been prepared through an inclusive stakeholder consultation process, including line ministries, research institutions, civil organisations, provincial governments, private sector, and international development partners. The main sources of information to prepare this document were the 7th and 8th Five-Year National Socio-Economic Development Plan (2011–2015 and 2016–2020), with a vision to 2030, the National Climate Change Strategy (2010), Forestry Strategy to the Year 2020 of the Lao PDR (2005), Renewable Energy Development Strategy (2011), Sustainable Transport Development Strategy (2010), Climate Change Action Plan of Lao PDR for 2013–2020 (2013), National Adaptation Programme of Action (2009), the Second National

Communication to the UNFCCC (2013), and Investment and Financial Flows to address climate change in the energy, agriculture, and water sectors (2015).

11. The ratified Paris Agreement on Climate Change to the UNFCCC on 7 September 2016.
12. The completion of the National Progress Reports on the Hyogo Framework for Action in five editions, (2005–2009, 2009–2011, 2011–2013, 2013–2015, and 2005–2015).
13. The completion of the Response and Preparedness Planning in three provinces: Vientiane Capital, Vientiane, and Bolikhamxay.
14. The development of the Guidelines on the Feasibility Study on the Emergency Operation Center Development for disasters.
15. The completion of the Contingency Plan of two provinces: Louang Prabang and Oudomxay (World Food Programme).
16. The ongoing awareness raising and education on climate change and disasters.

LAO PDR's efforts to implement key policies

1. Mainstreaming climate change and disaster management into the key sectors' policies, strategies, action plans, NSEDP 8 (2016–2020), and contributing to the achievement of SDGs and green growth.
2. Implementing climate change adaptation in relevant sectors, particularly the agriculture, forestry, and public health sectors.
3. Encouraging line ministries, private sectors, and relevant stakeholders to contribute to carbon trading through the Clean Development Mechanism (CDM) and the Joint Crediting Mechanism (JCM).
4. Completing Response and Preparedness Planning in three provinces: Vientiane Capital, Vientiane, and Bolikhamxay Province.
5. Establishing provincial, district, and vulnerable villages committees and coordinators.

Disaster Preparedness and Response Mechanism

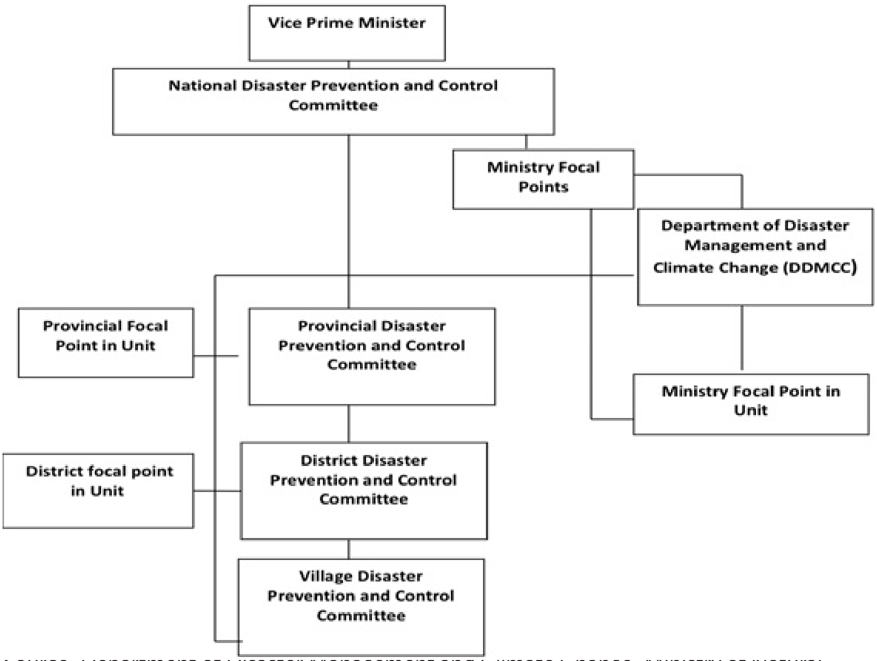
The National Disaster Prevention and Control Committee (NDPCC) has been established to support disaster management and climate change activities, including emergency and disaster response. Ministerial focal points play a key role in the day-to-day coordination and communication before and during emergencies, e.g. meetings with the Department of Disaster Management and Climate Change (DDMCC) prior to the monsoon period to assess resources' capacity to cope with emergencies; conduct situation analysis based on early warning information; planning and preparing for site visit, if necessary; and other related matters.

There are 13 main ministries involved in disaster management and climate change:

1. Ministry of Agriculture and Forestry (MAF), responsible for (i) seedling, replanting, nursery, structure recovery, etc.; and (ii) ensuring that local-based personnel and machineries are ready and checked regularly;
2. Ministry of Public Work and Transport (MPWT), responsible for (i) road, bridge and other public work recovery; and (ii) ensuring that local-based personnel and machineries are ready and checked regularly;
3. Ministry of Health (MOH), responsible for (i) ensuring that rapid physician teams are ready at national and local levels; (ii) preparing contracts on availability of medicines at pharmaceutical factories; (iii) preparing contracts on transportation with private transport companies; (iv) ensuring local hospitals and health care centres are ready, including increasing resiliency level; and (v) ensuring the availability of on-site clean water supply machines;
4. Ministry of Public Security, responsible for (i) rescuing and assisting affected populations; and (ii) ensuring availability of security guards and facilitating extreme and complicated events;
5. Ministry of Labor and Social Welfare (MLSW), responsible for providing (i) relief and humanitarian assistance; (ii) primary need items (food and non-food); and (iii) basic housing equipment;
6. Ministry of Education and Sport, responsible for the provision of (i) youth volunteers for rescue operations; (ii) information and communication to parents about the situation of their kids during emergencies; and (iii) school areas as evacuation sites/shelters;
7. Lao Red Cross, responsible for the provision of (i) relief and humanitarian assistance; (ii) first aid delivery; and (iii) rescue;
8. Ministry of National Defense, responsible for (i) provision of main personnel and machinery inputs during disaster events; and (ii) fast-tracking protocols for responding;

9. Ministry of Planning and Investment (MPI) in coordination with MONRE and line agencies, responsible for (i) consideration of outcomes of common rapid assessments for early relief and recovery proposals to the government; and (ii) medium- and long-term recovery and rehabilitation planning;
10. Ministry of Finance (MOF), responsible for (i) state reserve fund and (ii) cash and non-cash items (rice, fuel, etc.);
11. Ministry of Information, Culture and Tourism, responsible for (i) media and information disclosure regarding Early Warning System; and (2) recommendations on best practice/behaviour in emergencies;
12. Ministry of Foreign Affairs (MOFA), responsible for leading broader resource mobilisation efforts and issuing requests for assistance to the international community to support the national disaster response efforts;
13. Ministry of Natural Resources and Environment (MONRE)
(a) Department of Disaster Management and Climate Change (DDMCC), serves as the Secretariat to the NDPCC/government; prepares national disaster preparedness and emergency response plans, as well as strategic policy coordination of all disaster relief operations, and data collection and assessments;
(b) Department of Meteorology and Hydrology (DMH), responsible for weather-related early warning information, including weather forecasts, precipitation levels, and flood risk; provides hydro-meteorological and forecasting information, including warning bulletins to NDPCC, DDMCC and to sub-national government structures and the public; issues daily updates to DDMCC, via email, fax, or phone during the wet season; DDMCC contacts PDPCCs directly to share serious early warning; and prepares Early Warning System and recommendations for best practice/behaviour in emergencies.

National Disaster Management Structure in Lao PDR



Source: Department of Disaster Management and Climate Change, Ministry of Natural Resource and Environment (Lao PDR).

Lao Disaster Information System (LaoDi)

This initiative aims to strengthen the capacities of Lao PDR to provide information on disaster damage and loss to support national planning and the Sendai1 Framework. LaoDi provides authorised users with access to disaster data that enables them to monitor and analyse vulnerabilities in specific areas in Lao PDR, and share the collected data with line ministries and stakeholders. LaoDi was developed to record, store, and analyse loss and damage data in Lao PDR. It was established by DDMCC with technical and financial support from the United Nations Development Programme (UNDP) and the Asian Development Bank (ADB).

LaoDi has two modules: the Administration Module and the Analysis Module.

1. Administration Module is designed for authorised users such as the administrator or a super user. In this module, the user can (i) manage the database (add, update, or delete); (ii) manage the region (provinces, districts, and villages); (iii) manage the collected data (delete, modify, and update); (iv) manage the maps; and (v) create and manage other users.
2. Analysis Module is for general users to access. The user can (i) analyse the collected data by queries; (ii) identify the vulnerable areas by province and district but not yet by villages or by village cluster; (iii) identify the vulnerable areas by causes and types of disasters; and (iv) report the analysed result with graphs, tables, and maps.

LaoDi data can be exported to Microsoft Excel by statistics and crosstab statistics tools, while data analysis can be done using the chart and thematic map tool. Data analysis can be done at national, provincial, district, and village levels from selections of query criteria. LaoDi data is up and running and will be updated by DDMCC and MONRE. It is open and accessible to the public at www.laodi.laodisaster.gov.la.

LaoDi online application used DesInventar methodology (www.desinventar.net). The database platform and methodology have been implemented in 25 countries in the Asia–Pacific region as well as America, Africa, and Europe. LaoDi was established in Lao PDR by DDMCC after a series of consultation workshops between DDMCC officials and UNDP, followed by validation with key line ministries who will be provided with data on disaster loss and damage. LaoDi focuses on direct loss and damage data resulting from natural disasters in Lao PDR, including human life, housing, road, agriculture, education, and health. LaoDi data was collected from the Provincial Disaster Management Committee (PDMC), the District Disaster Management Committees (DDMC), the Ministry of Agriculture and Forestry (MAF), Ministry of Public Works and Transport (MPWT), Ministry of Labor and Social Welfare (MLSW), Ministry of Health (MoH), Ministry of Education, and the provincial departments of these line ministries.

Data on loss and damage from natural disasters are primarily collected from the Provincial Disaster Management Committee, which also is the focal point secretariat. However, if data is not available from PDMC, the data is based on the following ministries:

- Ministry of Labor and Social Welfare (MLSW) – data on human life and housing;
- Ministry of Pubic Work and Social Welfare (MPWT) – data on road sectors;
- Ministry of Agriculture and Forestry (MAF) – data on agriculture;
- Ministry of Health (MH) – data on hospital and health centres; and
- Ministry of Education and Sports (MES) – data on schools.

Currently available data in LaoDi:

- Historical data between 1990 and 2012 received from MLSW;
- Updated Data from the annual reports of DDMCC between 2014 and 2016;
- A total of 4,448 data card (records) up to district level with five main sectors (agriculture, education, health, labour, and road sectors);
- Around 150 road-related data: roads and bridges data;
- Around 50 data variables (data types): number of deaths of people; injured people; missing people; destroyed houses; destroyed crops; damaged roads; 16 main disaster events; floods; droughts; cool waves, and many more.

Expected data from LaoDi

- Direct disaster data of five main sectors: (i) agriculture; (ii) education; (iii) health; (iv) labour and social; and (v) road;
- Data variables will be more than 170 (e.g. number of people deaths, destroyed houses, etc.);
- Around 20 main disaster events (floods, droughts, cool waves, etc.); and
- Regular up-to-date data received from provinces via online data entry and up to village level.

LaoDi is still operated offline, but it works using the Local Area Network (LAN) of the DDMCC office.

Key Challenges

- Lack of human capacity in disaster risk management and emergency responses;
- Information and data are not yet updated;
- Some data and information are not yet available;
- Local infrastructure to support geo-based infrastructure is still young; and
- Lack of investment.

Keywords: remote sensing, economic development, challenge, technology independence.

Malaysia

Geospatial Technologies in Malaysian Disaster Planning and Management

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The ASEAN Socia-Cultural Community (ASCC) Blueprint 2015–2025 is a crucial step forward in creating a more resilient and self-sustainable community and region. This paper shares the Malaysian approach and hopes the cooperation and ASEAN spirit will lead to the materialisation of this highly valued blueprint.

The National Security Council (NSC) is a federal agency under the Prime Minister's Department mandated with the responsibility of managing and coordinating the implementation of policies related to the security of Malaysia and providing policies and mechanisms for national disaster management and relief. The three core functions of the NSC are: defending national sovereignty and strategic importance; crisis and disaster management; and border management of land, maritime, and air. The National Disaster Management Agency (NADMA) was set up in 2015 to coordinate government agencies tackling disasters such as the Malaysian Armed Forces, Police, Malaysian Civil Defence Department, Fire and Rescue Department, the People's Volunteer Corps (RELA), Social Welfare Department, and other relevant agencies. NADMA's Geographic Information System (GIS) Centre at Cyberjaya, which will be using the dashboard concept, is expected to be operational in 2018 with the Malaysian Space Agency (ANGKASA) providing geospatial data processing infrastructure and support. The core agencies providing geospatial data for disaster management are: Malaysian Meteorological Department (MMD), National Survey and Mapping Department (JUPEM), National Remote Sensing Agency (ARSM), ANGKASA, Malaysian Centre for Geospatial Data Infrastructure (MaCGDI), Public Works Department (JKR), and Drainage and Irrigation Department (JPS). Low-cost satellites are gaining interest from the state government and university research centres, especially for environmental monitoring. A framework of cooperation is being formalised for cooperation between Malaysian universities and ANGKASA on satellite research and development, with a low-cost micro-satellite program with Hokkaido/Tohoku University being planned. Research on deep learning and artificial intelligence has made a sound footing at local universities and there is a good potential to develop application systems from current research levels. Big data holds a major potential to contribute to disaster management and the role of MacGDI to enable data sharing, and a free flow of data will enhance the useful applications of geospatial data. The national geospatial policy currently being formulated will catalyse this cooperation. The use of high-precision satellite positioning will help in getting better mapping and location information for better disaster management decision-making. Currently, a high precision multi-global navigation satellite system (GNSS) is being tested at an oil palm plantation by the Japan Aerospace Exploration Agency, in collaboration with Keio University, Tokyo University, and Universiti Putra Malaysia. The results of such collaboration will not only benefit agriculture, but the resulting high-accuracy maps can aid in disaster management, particularly in flood mitigation. For greater acceptance of technology, the production of easy-to-operate and beneficial devices become necessary. The Internet of Things (IoT) is one example of such a development that has received support of the Malaysian Government. Plans are afoot to create an entrepreneurship industry in this field and the Malaysian Institute of Microelectronics Systems (MIMOS) has been entrusted with this leadership role. MIMOS has created a roadmap for the national IoT strategy (http://mimos.my/iot/National_IoT_Strategic_Roadmap_Summary.pdf).

The major cost component during disaster management implementation is logistics management, which can account for about 80% of the total cost of a disaster response. It is not only an issue of cost, but also the need for timely and efficient coordination as disaster logistics management is currently being handled by multiple government organisations with different objectives and stakeholders. Although each agency has a working logistics management system, there is no apparent communication with each other. There is no real-time system on the availability and current location of resources and assets that have been allocated for the purpose. Based on feedback from experienced ground personnel who have been involved in dozens of disaster operations, the main problem that needs to be addressed is the communication problem. The communication flaws are due to the weaknesses of the personnel, the weaknesses of some agencies' standard operating procedures (SOPs), command and order, and the radio emergency communication system itself.

The empowerment of local communities against natural hazards not only supports disaster prevention efforts but, when implemented as a web GIS as in the case of Ulu Klang Highlands community, helps in the development of a community-friendly web GIS-based information system; the integration of the website with data from meteorological and other relevant sources; the empowerment of the community to upload relevant environment sensitive information; and the production of updated maps that can be printed and downloaded by local residents. These brought benefits to the residents as they were able to view and have easy access to the map and other relevant information on the web, such as rainfall data. They can be active players in monitoring their local topography and environment and can link directly to meteorological and other external data sources.

Based on the assessment of the current situation, some potential projects that can benefit from the integrated use of space and geospatial technologies are cross-boundary haze, illegal human trafficking, crowd sourcing information, and illegal land cutting and land clearing.

Although there is ASEAN cooperation and agreement on trans-boundary haze pollution, well-integrated and efficiently executed geospatial applications will help in the success of combating trans-boundary haze, especially through effective data sharing procedures. Illegal human trafficking is also a problem awaiting a geospatial solution. This activity is directly a geospatial phenomenon as no illegal human trafficking can occur without the geographical movement of the victim. Current mobile telephone technology can be an innovative tool in helping trace this illegal human movement. As greater masses of people are exposed to technology, the time is ripe for educating and cultivating crowd sourcing data from people on the ground. In the case of Malaysia, the Civil Defence Agency alone has one million people who are ground volunteers. Tools such as low-cost, high-accuracy multi-GNSS receivers will enable these volunteers to supply ground data with very high accuracy. As for land cutting and clearance activities, the monitoring and enforcement of illegal and dangerous cutting and clearing of land can help avoid landslides, mud floods, and related disasters, which have had catastrophic consequences in the past.

In conclusion, it is indisputable that space and geospatial data are critical requirements for building a resilient society. The use of these data, together with data infrastructure and data sharing, is a fundamental part of a resilient system. Communication, training, and retraining are vital components of capacity building that cannot be overlooked. With the current pace of technological changes, having a society that is up-to-date, knowledgeable, and skillful in the use of geospatial technology will be an asset to the country and the ASEAN region. The wisdom and efficiency in utilising these geospatial technologies will ensure a safe and secure society for generations to co me.

Myanmar

Presentation Summary by Myanmar on the ERIA Research Project Wrap-up Meeting

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Myanmar is prone to natural disasters and the frequency and intensity of these disasters are increasing. According to global reports, Myanmar ranks 42 out of 171 countries in terms of disaster frequency, while it ranks 15 in terms of disaster response readiness.

After the catastrophic cyclone Nargis in 2008, which triggered damage and loss of about 21% of total gross domestic product (GDP) in the 2007 fiscal year, Myanmar had put emphasis on disaster risk reduction. The country bears an average annual loss of about 3% of GDP due to natural disasters. In 2015, it also suffered nationwide flood and severe landslides in the mountainous regions, especially in the western part of the country, with damage and losses reaching 3.1% total of GDP. The Government of Myanmar has laid down its development vision – 'A developed nation (middle-income country) that is integrated into the global community' – in its National Comprehensive Development Plan (NCDP) 2030. A disaster can draw back its development gains and can interrupt the development and sustainability of the country. Thus, to achieve resilient development in Myanmar, the National Disaster Management Committee (NDMC), chaired by the Vice President of the Government of the Union of Myanmar, has been tasked with promoting the disaster management system in Myanmar in line with global and regional frameworks.

The NDMC is the highest decision-making body and there are 12 working committees under its supervision. The Relief and Resettlement Department (RRD) of the Ministry of Social Welfare is the focal department for disaster management. Myanmar also enacted the Disaster Management Law (2013) and Disaster Management Rules (2015), as law enforcement is necessary to ensure that disaster risk reduction and management activities are carried out without any interruption. Moreover, the Myanmar Government developed the Myanmar Action Plans on Disaster Risk Reduction (MAPDRR) 2012, and it is now under revision in line with the Sendai Framework for Disaster Risk Reduction (SFDRR), the sustainable development goals (SDGs), and other regional and global frameworks.

Based on the experience and lessons learnt from the 2012 MAPDRR, the 2017 MAPDRR will be comprised of four areas which include: 'Assessing disaster and extreme events risk and creating public awareness on DRR in Myanmar'. There will be eight priority actions for risk reduction by mainly applying the space-based and geospatial technologies.

Since 2012, Myanmar has been upgrading its disaster management system by utilising advanced technology like space technology and it received the Technical Advisory Mission (TAM) of the United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN–SPIDER) of the United Nations Office for Outer Space Affairs (UNOOSA). The TAM recommended the extensive use of space technology in disaster management. The Myanmar Government understands that advanced and technology-based disaster management mechanisms have become the crucial and necessary requirements for a community that is resilient to natural disasters and for sustainable development. The RRD reformed its organisational structure by establishing the Emergency Operations Centre (EOC) as one of the operating organs of RRD in 2013. EOC is comprised of four units, including a technical unit for handling space-based and geospatial information. This technical unit is still in the nurturing stage, until the human resource becomes capable of analysing the satellite imageries and risks to contribute to disaster management activities. It is still necessary to get the capacity development measures for the technical skills improvement and experiences as well.

Myanmar also tried to be a member of international communities utilising space technology in disaster emergency and management, and it got the technical assistance and data and information in disaster emergency from Sentinel Asia and the International Charter. Being a member of the Asian Disaster Reduction Centre (ADRC), Myanmar has the right to request data from Sentinel Asia. RRD, Myanmar's national disaster management organisation, has become the authorised user of the international charter to achieve a speedy activation process. Moreover, Myanmar has the option to access space technology, which is in line with the procedural guidelines on the 'utilization of Earth observation data during emergency response' developed for the ASEAN group.

Furthermore, RRD tried to allocate budget for purchasing high-resolution satellite imageries in the next fiscal year to have the chance to utilise satellite imageries at the relocation stage after some disaster emergencies and risk assessment measures. In addition, the training course on Geoinformatics Applications in Disaster Management has been developed and this course is being used in the Disaster Management Training Centre (DMTC) of RRD to train government officials and staff who are responsible for disaster management in Myanmar. The objective of the training is to 'raise awareness amongst the participants and to develop basic skills for effectively utilising the Geographic Information Systems (GIS) and remote sensing (RS)/space-based information in disaster management'. This course is comprised of four modules – Disaster Management Terminologies and Concepts; Introduction to GIS, Remote Sensing, Global Positioning System (GPS) and Internet Mapping Services; Geoinformatics for Mapping and Monitoring of Hazards, Vulnerability and Risk Assessment; and Geoinformatics for Disaster Management Planning and Emergency Response.

Disaster risk reduction and management is the cross-cutting issue and it is very crucial for national development and sustainability. To ensure sustainable development, it is vital to be disaster resilient and disaster risk reduction measures are critical for making the best use of space-based and geospatial technologies. Moreover, it is important to disseminate the results and products acquired from these technologies not only to concerned agencies to enable them to practice using them in their work in DRR but also to the communities for their awareness raising. Exchanging knowledge and best practices on using space-based and geospatial technologies through regional and global meetings and workshops are very helpful to widely use and apply the technologies in disaster management.

Philipines

Disaster Risk Reduction and Management (DRRM) in the Philippines and the Southeast Asian Region through Space Technology

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The Philippines is located near the equator and along the Pacific Ring of Fire, which makes it vulnerable to natural disasters such as typhoons, earthquakes, and volcanic eruptions, endangering the natural resources and biodiversity that the country is endowed with. A major disaster that struck the Philippines was Typhoon Haiyan (local name: Typhoon Yolanda). The typhoon caused damage estimated at ₱89.6 billion (US$1.77 billion), with 6,300 deaths and 1,081 missing. This scenario is a major concern for the Philippines and measures need to be adapted given that a similar disasters may occur in future given the country's location. An effective Disaster Risk Reduction and Management (DRRM) measure that can be taken by the country is the use of space technology, particularly satellite technology.

The country is gradually emerging as a space-faring nation, as evidenced by its continuous space development efforts throughout the past years. Looking ahead, the Philippines, through the National Space Promotion, Awareness, and Capabilities Enhancement (SPACE) Development Program (or NSDP), developed strategic roadmaps for the future space programme of the country. These roadmaps include the Satellite Development Roadmap, which contains the satellite requirements of the Philippines for the next 15 years. Satellite technology for the Philippines would bring enormous benefits for the country, particularly on applications for national security, agriculture, and disaster management. While all the satellites being planned by the Philippines have a direct or indirect application for disaster management (in terms of communications and Earth observation applications), there are satellites that greatly contribute to this use. Planned satellites that have immense applications for disaster management include a synthetic aperture radar (SAR) satellite and a microwave satellite for precipitation monitoring.

The coupled use of SAR and microwave satellites can greatly enhance DRRM efforts throughout the country. By measuring precipitation and rainfall using a microwave satellite, combined with data from the SAR satellite, timely comprehensive results can be distributed to various decision-makers and policymakers in critical times of disasters, thereby enhancing humanitarian aid for the affected areas.

Given this strategic plan of the Philippines to develop satellites for disaster management and being in a prominent location for typhoons and disasters, the country can lead the way for the Southeast Asian Region. As the country is strategically located between the Pacific Ocean and mainland Southeast Asia, typhoons mostly cross the Philippine archipelago onto either East Asia or Southeast Asia, putting the country at the forefront of typhoons. Therefore, an effective utilisation of satellite technology for disaster management in the country would help the whole region as it would reduce the risk of disaster for the other countries. An 'ASEAN Satellite Constellation' of SAR and/or microwave satellites would prove valuable for the region, as it would mean greater regional coverage.

However, the physical infrastructure for satellite technology would not be effective without satellite information sharing. Thus, there is a need for the countries in the region to engage in satellite information sharing to promote interoperability and interconnectivity throughout the region in terms of satellite technology. A Satellite Data Sharing Policy for the Southeast Asian Region on disaster management, consonant with each country's policies and not endangering the security of each nation, would prove useful.
Lastly, a regional centre for water information can be established in the Philippines to pool researchers and technologists from Southeast Asia and to facilitate satellite data sharing amongst countries. This regional centre can be the centerpiece in Southeast Asia in terms of utilising water information for disaster management.

The Philippines has been at the forefront of disasters and typhoons in Southeast Asia, as manifested by 2013 Typhoon Haiyan that struck the country. No other typhoon to date matches the devastation it brought. With the Philippines slowly emerging as a space-faring nation, plans for its future space programme, and the development and utilisation of various satellites for disaster management are at the forefront of its strategy. The use of SAR and microwave satellites, not only in the Philippines but also in Southeast Asia, would be valuable. A satellite data sharing policy for the region should also be discussed to effectively utilise the satellite data. Lastly, a regional centre for water information can be established in the Philippines, which would play a vital role in the region in the facilitation of water information and research.

Thailand

Thailand Disaster Risk Management Using Space Technology

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Thailand is less susceptible to natural hazards than the other countries in the Asia–Pacific. The geography and location of Thailand help insulate the country from many of the impacts of meteorological and geophysical natural disasters. However, Thailand's agricultural industry and highly developed urban areas leave sizable portions of the population and the economy vulnerable to disasters such as flooding, drought, landslides, and forest fires.

Over the past 2 decades, space technology has become a significant part of Thailand's daily lives and it plays important roles in disaster risk reduction and management. Thailand has been involved in satellite remote sensing since the launch of NASA's Earth Resources Technology Satellite 1 (ERTS-1) Programme in 1971 through the Thailand Remote Sensing Programme (TRSP) under the National Research Council of Thailand (NRCT). In 2000, Geo-Informatics and Space Technology Development Agency (GISTDA), a public organisation, was established to enhance the utilisation of remote sensing and the geographic information system (GIS). GISTDA is responsible for space technology application in Thailand, particularly disaster management. The Thailand Monitoring System (TMS) was initiated by GISTDA to cope with and monitor disasters and it publishes online analytic geo-information from satellite imagery daily for related organisations and the private sector. The system includes flood, drought, and forest fire, and can be accessed at tms.gistda.or.th.

Flooding is the most serious hazard in Thailand and every part of the country struggles with flood-related damage every year. During the monsoon season in Thailand, GISTDA monitors the flood situation and agricultural areas every seven days. GISTDA uses RADARSAT data to monitor agricultural areas and evaluate damaged zones for general areas; and Cosmo-SkyMed data to monitor critical areas due to its constellation capability (four satellites). Hourly, daily, weekly, and monthly rain cloud information from COMS (Communication, Ocean and Meteorological Satellite) satellite are available to the government and are published online via web service (flood.gistda.or.th).

Drought is an increasingly serious hazard for parts of central and eastern Thailand. Drought conditions are most common from January through to May and are alleviated by the onset of the monsoon season. GISTDA uses a set of MODIS data (seven days) to calculate drought indices, normalised difference vegetation index (NDVI), and normalised difference water index (NDWI) for drought risk area assessment and these are published weekly at http://drought.gistda.or.th. This information is necessary for the government to warn and assist farmers. Moreover, surface water database from LANDSAT satellite image has been collected for drought monitoring as it is an indicator of water shortage. GISTDA also developed the Field Server Ground Station to automatically collect field data such as humidity, soil moisture, rain volume, crop growing, etc. This data will be integrated with satellite data for precise data. Currently, there are 25 stations spread across the whole country in different crop types.

Forest fires occur during the dry season from December to May, with their peak in February to March. Fires, mostly classified as surface fires, mainly occur in mixed deciduous forests, dry dipterocarp forests, forest plantations and, to some extent, dry evergreen forests, hill evergreen forests, or even in some parts of the tropical rainforest. These surface fires consume surface litter, other loose debris on the forest floor, and small vegetation. In Thailand, forest fire is reported daily (fire.gistda.or.th) and the Transport Management System publishes daily hotspots using TERRA/AQUA–MODIS data such as haze and smoke. GISTDA also generates weekly wildfire risk areas analysed from hotspots accumulated for 10 years, land use, burnt NDWI areas, and weather to predict the fire trend each year. Every 16 days, data about burnt areas are extracted using LANDSAT-8 satellite image. GISTDA established the GISTDA Forest Fire and Smoke Operation Center in nine provinces in northern Thailand where forest fire is a common issue. These centres will receive remote sensing and GIS data from GISTDA to support forest fire management and the training of experts on data interpretation and effective use of GISTDA forms. Currently, GISTDA receives daily hotspot data from SUOMI–NPP satellite (twice a day), integrated with data. By doing this, Thailand will have more detailed information on forest fire and the number of hot spots may significantly increase because the number of rounds and resolution of the satellite. Mobile application for alerts and reports on the situation in the fire area was developed to get more precise fire location data.

Based on GISTDA experiences, space technology will play a vital role in disaster management in the future. Satellite images give overview information of disaster situations, which are necessary for understanding, management, and decision-making. Precise location information on the constellation of GNSS will lead to the exact location for timely rescues and assistance. Correct information integrated with appropriate management processing and new technology will result in rapid resolution of a situation. For example, the hot spot situation in the northern part of Thailand has continued to decline every year because sufficient information from space technology has led to the understanding and management of the right points and locations.

Keywords: space, technology, natural disasters, Thailand

Viet Nam

Potential of Geospatial/Space-based Service in Viet Nam

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Vietnam National Satellite Center

The 2016 World Disaster Report showed that Viet Nam is one of the five countries in the world that has been most affected by natural disasters and climate change. In the last 10 years, according to the Ministry of Natural Resource and Environment (MONRE), there have been around 500 deaths and the damage caused by disasters is estimated at 1.5% of the country's GDP per year. There are many types of disasters in Viet Nam. The top five high frequency disasters are: flooding, storm, drought, flash flooding, and erosion/sedimentation.

Space-based services for disaster management in Viet Nam are currently used by research institutions as well as management agencies. Viet Nam is building up an infrastructure for geospatial data called Viet Nam Data Cube. This will be an open sharing system for all available geospatial data in Viet Nam, including free satellite data such as Landsat, MODIS, Sentinel; Viet Nam's satellite data (VNREDSat 1; LOTUSat 1 and 2); and other data. Viet Nam Data Cube is being built based on the data cube (http://ceos-cube.org/). It will provide ease of use and access to space-based data with multiple dataset interoperability and spatial consistency. It is also combined with built-in data processing algorithm and API (application programming interface), which can be used for 'Analysis Ready' data products for all users. Viet Nam Data Cube was planned to be launched in January 2018 with two applications: forest monitoring and water quality monitoring. The opening of the space-based data and service of Viet Nam Data Cube can be considered for space-based service for disaster management in Viet Nam as well as in other ASEAN countries. However, the investment issues that need to be clarified are: infrastructure (Data Cube-based); data system (Data Cube similar); software; trained professionals; and web-based services system. This system will help ASEAN countries have a shared understanding, Earth observation and geospatial data, and help in early warning and rescue information.