# Chapter 18

# Environment and Sustainability

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# Introduction

Many economies of Asia are in the midst of the great information and communication technology (ICT) revolution. Over the last five decades, the Association of Southeast Asian Nations (ASEAN) as an economic bloc has successfully transformed its member economies by investing in the continuous upgrading of their industrial infrastructure, technical expertise, knowledge, and skills. As a result of historical economic development driven by industrialisation and population growth, ASEAN Member States (AMS) have also witnessed an unprecedented increase in carbon emissions and other resource consumption, pollution, and consequent environmental system change.

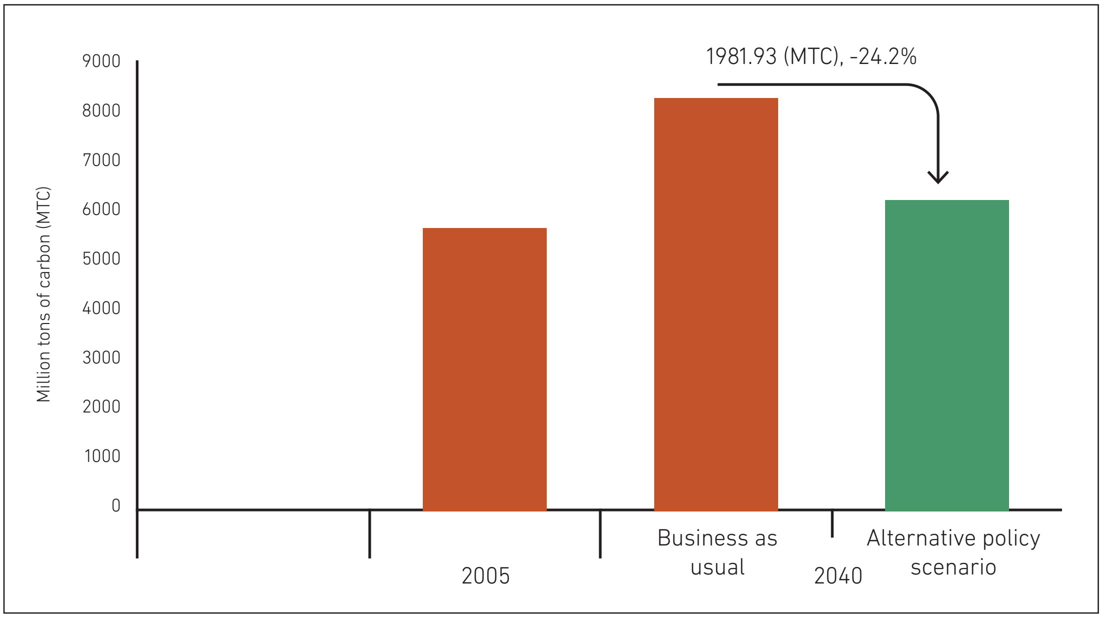
The third unbundling – which will encompass clusters of transformative technologies in the domain of information technology (IT) and communication technology, such as artificial intelligence (AI), the internet of things (IoT), robotics, 3D printing, neurotechnology, drones and autonomous vehicles, biotechnology, virtual and augmented reality, and blockchain, along with the evolution of big data – could offer innovative approaches to managing environmental footprints and improve livelihood conditions. The region must take advantage of this rapid technological change to make the industrialisation and development more sustainable. While the environmental challenges faced by the region are multiple and complex, and need stronger commitment, rapid technological change provides opportunities that were previously out of reach for governments, the private sector, and the poor. This section outlines the environment and sustainability challenges posed to the fast-growing economies, which would undermine the quality of life, and discusses the opportunities available with an emerging set of smart technologies.

# Environmental Sustainability Challenges in ASEAN

Southeast Asian countries are not only rich in natural biodiversity and culture but also have some of the fastest growing regional economies in the world. A combination of rapid economic development, demographic shifts, and rising living standards is posing a new set of environmental sustainability challenges to meet increased food, energy, and material demand. A range of socio-economic mechanisms (e.g. trade, migration, and demand for goods and services) as well as natural phenomena such as climate change and disaster transmits the pressures from country to country. The following issues need to be addressed urgently from an environmental perspective:

- **Greenhouse gases:** ASEAN accounts for 1,666 million tons (Mt) of carbon dioxide (CO2) emissions – 4% of the world total – mostly from fossil fuel use, which accounts for 550 million tons of oil equivalent (Mtoe) or 5% of the world total (Figure 18.1).

**Figure 18.1 Total Carbon Emissions from the Region**




Source: Kimura and Han (2021).

- **Biodiversity:** The region – the second richest – is rapidly losing its biodiversity at mass extinction rates, such that 40% of its genetic biodiversity has become extinct.

- **Deforestation:** The current deforestation rate in tropical forests leads to a 7% drop in regional rainfall. As the region rapidly urbanises, more people than ever before demand land, wood, mineral, and other resources. Table 18.1 shows some indicators related to deforestation, climate risk, and resource use.

**Table 18.1 Selected Indicators of Sustainability and Resilience in ASEAN**

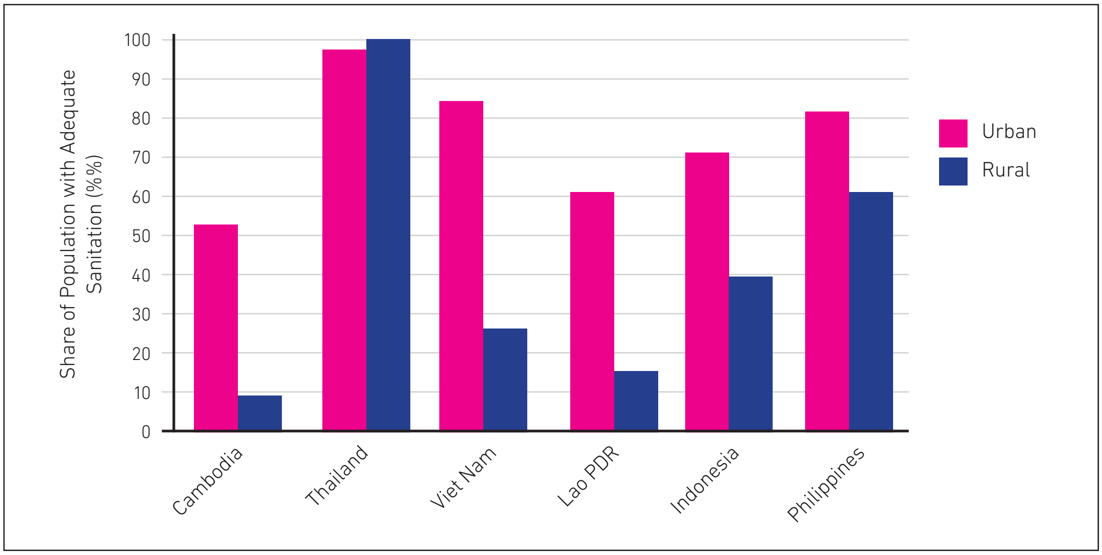
| Country | Proportion of population practising open defecation (%) | | Material footprint per capita (ton) | | Forest area as a proportion of total land area (%) | | Climate Risk Index score (rank) |
|---|---|---|---|---|---|---|---|
| | 2000 | 2015 | 2000 | 2017 | 2000 | 2015 | 2016 |
| Brunei Darussalam | 2.5 | 2.6 | 12.60 | 19.09 | 75.33 | 72.11 | 109.50 (120) |
| Cambodia | 82.7 | 40.6 | 1.66 | 3.57 | 65.41 | 53.57 | 95.17 (111) |
| Indonesia | 32.2 | 12.4 | 3.36 | 6.23 | 54.87 | 50.24 | 46.17 (37) |
| Lao PDR | 62.0 | 22.1 | 1.26 | 7.37 | 71.60 | 81.29 | 109.50 (120) |
| Malaysia | 1.6 | 0.3 | 19.19 | 22.61 | 65.72 | 67.55 | 65.50 (72) |
| Myanmar | 11.2 | 4.7 | 0.53 | 1.50 | 53.39 | 44.47 | 57.17 (53) |
| Philippines | 10.9 | 5.7 | 4.00 | 4.34 | 23.57 | 29.96 | 31.33 (16) |
| Singapore | | | 51.14 | 73.04 | 23.06 | 23.06 | 109.50 (120) |
| Thailand | 1.0 | 0.3 | 7.75 | 14.90 | 33.30 | 32.10 | 37.50 (20) |
| Viet Nam | 17.7 | 3.9 | 3.42 | 10.01 | 37.82 | 47.64 | 15.33 (5) |

ASEAN = Association of Southeast Asian Nations.

Source: United Nations (n.d.), SDG Indicators Database. https://unstats.un.org/sdgs/indicators/database/ (accessed 5 August 2018).

- **Water cycle:** Fresh water bodies such as lakes, rivers, and irrigation tanks are facing severe impacts in terms of water availability and quality, mainly because of over-abstraction of groundwater and uncontrolled pollution. This could result in a 30% shortfall in fresh water in 2030 (Raghavan et al., 2019). Changes in water availability and quality have profound effects on sanitation conditions in both urban and rural areas (Figure 18.2).

**Figure 18.2 Share of Population with Adequate Sanitation**
(%)




Source: ADBI (2014).

- **Solid and industrial waste:** As economies grow, individuals become rich and consume and discard more. ASEAN, China, and India account for one-third of the world's population but produce 29% of its waste; this is expected to double by 2050. Jambeck et al. (2015) calculated the quantity of plastic marine debris in each country, based on the population within 50 kilometres of the coast, waste generation per capita, the percentage of plastic waste, and the percentage of mismanaged waste. They pointed out that China was the top generator of marine plastic litter, followed by Indonesia, the Philippines, and Viet Nam (Table 18.2), while Thailand, Malaysia, and Myanmar are also in the top 20. Growing Asian countries are regarded as a major source of land-based plastic marine debris because of the increased use of plastics and insufficient waste collection services.

**Table 18.2 Marine Plastic Debris Challenges in ASEAN and East Asia**

| | Country | Coastal population (million) | Waste generation (kg/ppd) | Percent of plastics | Percent of mismanaged waste | Plastic marine debris (MMT/year) |
|---|---|---|---|---|---|---|
| 1 | China | 262.9 | 1.10 | 11 | 76 | 1.32–3.53 |
| 2 | Indonesia | 187.2 | 0.52 | 11 | 83 | 0.48–1.29 |
| 3 | Philippines | 83.4 | 0.50 | 15 | 83 | 0.28–0.75 |

| | Country | Coastal population (million) | Waste generation (kg/ppd) | Percent of plastics | Percent of mismanaged waste | Plastic marine debris (MMT/year) |
|---|---|---|---|---|---|---|
| 4 | Viet Nam | 55.9 | 0.79 | 13 | 88 | 0.28–0.73 |
| 6 | Thailand | 26.0 | 1.20 | 12 | 75 | 0.24–0.64 |
| 8 | Malaysia | 22.9 | 1.52 | 13 | 57 | 0.14–0.37 |
| 12 | India | 187.5 | 0.34 | 3 | 87 | 0.09–0.24 |
| 17 | Myanmar | 19.0 | 0.44 | 17 | 89 | 0.05–0.12 |

ASEAN = Association of Southeast Asian Nations, kg = kilogram, MMT = million metric tons, ppd = per person per day.
Source: Jambeck et al. (2015).

- **Climate change and disasters:** The impacts of natural disasters are more pronounced in ASEAN than in other parts of the world. By 2050, the impact of climate change is projected to reduce the annual gross domestic product (GDP) of ASEAN by up to 6% per year.

The policy community is also concerned that these impacts might interconnect to trigger cascading negative feedback loops, which could flip the economic and social systems into a wholly new state. If no concrete actions are taken, the future is likely to begin a period of sustainability disequilibrium that could affect the quality of life.

## Circular Economy: Motivating Sustainability Through Resource Efficiency

'Circular economy' is an umbrella term used for industrial processes and business models which do not generate pollution and waste but, rather, reuse natural resources repeatedly. At its core, the circular economy is about economics and competitiveness. Its approach to resource efficiency integrates cleaner production and industrial ecology in a broader system, encompassing industrial firms or networks of firms to support resource optimisation. At the individual firm level, higher resource efficiency is sought through the '3Rs' – 'reduce' consumption of resources, 'reuse' resources, and 'recycle' the by-products. Sustainable product and process design are important circular economy plans. In such a business model within the circular economy, instead of selling products to consumers, companies can retain ownership of the physical products and consumers only pay for the use they derive from them.

At a national level, emerging economies of Asia can boost environmental sustainability by supporting shifts towards a new industrial process which minimises waste and focuses instead on resource recovery. This has similarities with Industry 4.0, which is often cited as the fourth major upheaval in modern manufacturing – following the lean revolution in the 1970s, the outsourcing phenomenon of the 1990s, and the automation that took off in the 2000s. It is also defined as the next phase of powerful technologies that have strong potential to step up competitiveness and create differentiated products.

The basket of new digitally enabled technologies that include advances in production equipment are 3D printing; advanced robotics; smart finished products such as connected cars and home appliance systems using IoT; advanced analytics such as big data analytics and analytics across the global value chain; human–machine interfaces such as technology using augmented reality; and AI. These transformative technologies, included under the Industry 4.0 framework with data analytics as a core capability, have the potential to speed up the circular economy transition as illustrated in Table 18.3. If the elements of these two framework notions (Industry 4.0 and circular economy) are compared, it is striking that similar concepts emerge. Both the circular economy and Industry 4.0 are based on (i) a change in the approach of producers and customers, (ii) new product and process offerings, and (iii) the integration of value chains.

**Table 18.3 Technological Developments for Industry 4.0 and the Circular Economy**

| Technological developments for industry 4.0 | Transformative technologies for the circular economy |
|---|---|
| • Information and communication technology<br>• Cyber-physical systems<br>• Network Communications – internet of things (IoT)<br>• Simulation<br>• Advanced data analytics<br>• Robits, augmented reality, and intelligent tools for support of human workers | • Mobile technology<br>• Machine-to-machine communication<br>• Cloud computing<br>• Social media for business<br>• Big data analytics<br>• Modular design technology<br>• Advanced recycling technology<br>• Trace and return systems<br>• 3D printing |

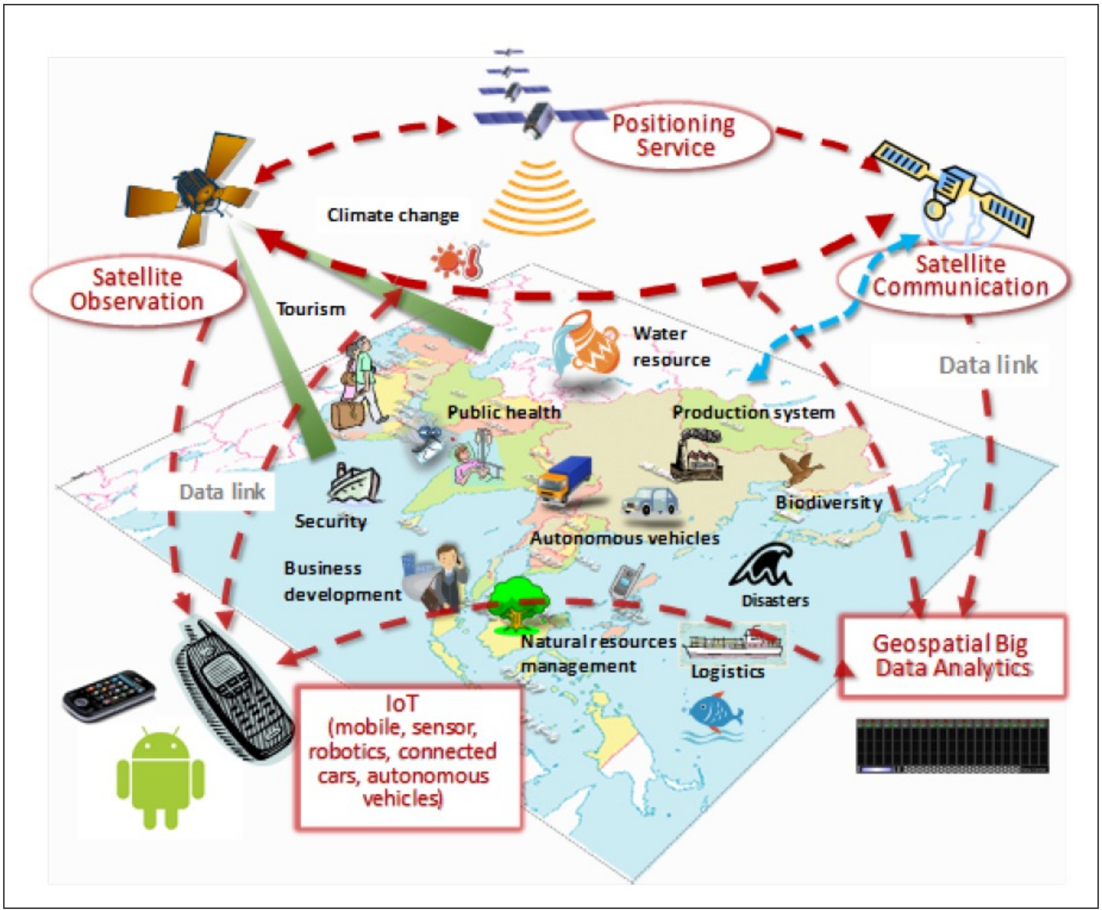
Source: Anbumozhi and Kimura (2018).

This is because the circular economy, with its focus on recycling, innovation, and skills development, is inherently more labour-intensive than the linear industrial production model of 'take, make, waste', but uses less energy and raw materials. Through this systemic approach and the integration of technologies, the circular economy has the ambition to minimise the material usage per unit of functionality and to manage materials in the system in such a way that losses and emissions are minimised. In many countries of Asia, resource use policy is typically based on the 3Rs: reuse, reduce, recycle. Waste management is considered to be an important and urgent environmental challenge under this paradigm, wherein waste handling and disposal becomes a key policy agenda. On the other hand, the concept of the circular economy creating economic value for the resource use adds upstream measures (e.g. in the product design) to this 3Rs principle. Closing the cycle of production and waste disposal keeps products in use longer, recycles products endlessly, and ultimately uses less to produce more. In the circular economy vision, all products are ultimately broken down into either technical nutrients which are made into new products, or biological ones which return to the soil.

## Potential of Integrated Smart Digital Technologies for Improved Environmental Sustainability

The rise of AI and smart digital technologies has resulted in three domains: satellite-based earth observation technology, positioning technology, and communication technology (Shibasaki et al., 2018). This integrated technology system can be seen as global IT, providing communication services anywhere using dynamic information on the physical, socio-economic and demographic, and environmental aspects of regions such as Southeast Asia. This technology is easily enhanced by space infrastructure, as illustrated in Figure 18.3, to cover ASEAN and East Asia in a seamless manner.

## Figure 18.3 Data Infrastructure and Supporting Smart Technologies to Address Environmental Challenges




IoT = internet of things.

Source: Shibasaki et al. (2018).

This integrated intelligence system could provide diverse data and information services using 'real-world data'. More concretely, the four major services and contributions of such systems may be summarised as follows:

(i) Real-time localisation and tracking of people: cargo and vehicles (air, sea, and land).
(ii) Real-time monitoring of environmental and contextual information covering all land and sea: dynamic maps (e.g. traffic, congestion, people flow, and city changes) or environmental changes (e.g. weather, water and air quality, deforestation, solid waste generation, and greenery) from which events, accidents, and disasters can be extracted. Silent but meaningful changes such as climate change, marine debris, sanitation, and crustal deformation can be included.
(iii) 'Ubiquitous' data communications at any time/anywhere with small IoT devices to collect data from and to send instructions/guidance to people and machines in the field.
(iv) High-precision mapping of 3D space and landscape framing activities of people and autonomous vehicles/machines, which could include very slowly moving phenomena such as crust movement monitoring.

The following steps describe how those smart technologies would contribute to climate change adaptation and disaster resilience via real-time tracking, monitoring, mapping, and ubiquitous data communication capabilities:

- Monitoring and forecasting natural hazards at the local to regional scale – typically heavy rainfall, flooding, typhoons, droughts, and tsunami – to let governments and people know what could happen.
- Anticipating risks or damage to human lives and economic activities by overlaying the hazard prediction based 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 population distribution data and helping the reconstruction of people's lives and economic activities.
- Improving preparedness by providing realistic simulations and training on disaster risk management based on historical records of disasters and reconstruction processes.

The steps outlined above are made possible by sharing data amongst governmental agencies, private industries, non-profit organisations, and people. In this regard, 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, 2016: 11): 'Promote regional standards, including methodologies and tools to assess, record, calculate the disaster losses and damages, and share non-sensitive data and create common information system, to enhance interoperability, ensure unity of action, and strengthen resilience'.

Further, in June 2018, ASEAN leaders adopted the Bangkok Declaration on Combating Marine Debris in ASEAN Region (ASEAN, 2018), which declared that AMS should strengthen actions at the national level as well as through collaborative action amongst the AMS and partners to prevent and significantly reduce marine debris, particularly from land-based activities, including environmentally sound management. In the past, improper waste management was regarded as a local environmental problem. But due to the marine debris issue, waste management is becoming part of the solution to the emerging global environmental problem, i.e. marine plastic issue, in addition to other measures such as reducing single-use plastics.

Real-time positioning by remote sensing 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. The mobility data of people, vehicles, ships, and aircraft are widely available. Geostationary satellites are commonly used in ASEAN and East Asia for data communication. However, adequate miniaturisation of ground transceivers, combined with the use of low earth orbit satellite constellations, will increase access to efficient communication and dramatically reduce costs in the near future.

Therefore, the digital, ICT, and big data systems should be smartly and strongly designed to capitalise on the potential multiple benefits of their use to bring community resilience. On the other hand, they also represent a technology system that is a highly efficient and inclusive information system. In reality, all three components of the system are addressed through separate initiatives, requiring close cooperation and coordination amongst academia, industry, and government. Such complexity and uncertainty typically confront the challenge of total costs, which have to be reduced as much as possible.

## Readiness of ASEAN and East Asia to Embrace Industry 4.0 or Smart Technologies

The potential to harness smart, digital, and Industry 4.0 technologies to achieve environmental sustainability and resilience – or, more fundamentally, redesign how human, technological, and economic systems interact with the natural environment through cities, transport and energy networks, agricultural production systems, industrial value chains, waste management, and disasters preparedness – appears to be boundless. Table 18.4 illustrates the development level of new technological applications that address the challenges of the circular economy, sustainability, and resilience in the emerging markets of ASEAN.

## Table 18.4 Development Level of Smart Technologies to Address Sustainability Challenges in ASEAN

| Industry 4.0/ smart/digital ICT technologies | Emission reductions and the sharing economy | Resource management and the circular economy | Preventing pollution | Protecting biodiversity | Resilience and climate change adaptation |
|---|---|---|---|---|---|
| 3D printing | Potential being explored extensively in some markets | Potential being explored extensively in some markets | Potential being explored extensively in some markets | Potential being explored extensively in some markets | Potential being explored extensively in some markets |
| Artificial intelligence | Being introduced in some niche markets but not to scale | Being introduced in some niche markets but not to scale | Being introduced in some niche markets but not to scale | Being introduced in some niche markets but not to scale | Being introduced in some niche markets but not to scale |
| Advanced materials | Potential being explored extensively in some markets | Potential being explored extensively in some markets | Being introduced in some niche markets but not to scale | Potential being explored extensively in some markets | Potential being explored extensively in some markets |
| Advanced sensor platforms | Being introduced in some niche markets but not to scale | Being introduced in some niche markets but not to scale | Being introduced in some niche markets but not to scale | Being introduced in some niche markets but not to scale | Being introduced in some niche markets but not to scale |
| Biotechnologies | Potential being explored extensively in some markets | Potential being explored extensively in some markets | Being introduced in some niche markets but not to scale | Potential being explored extensively in some markets | Potential being explored extensively in some markets |
| Blockchain | Potential being explored extensively in some markets | Potential being explored extensively in some markets | Potential being explored extensively in some markets | Potential being explored extensively in some markets | Potential being explored extensively in some markets |
| Drones and autonomous vehicles | Being introduced in some niche markets but not to scale | Being introduced in some niche markets but not to scale | Potential being explored extensively in some markets | Being introduced in some niche markets but not to scale | Potential being explored extensively in some markets |
| Internet of things | Being introduced in some niche markets but not to scale | Being introduced in some niche markets but not to scale | Potential being explored extensively in some markets | Potential being explored extensively in some markets | Potential being explored extensively in some markets |
| Robotics | Being introduced in some niche markets but not to scale | Being introduced in some niche markets but not to scale | Being introduced in some niche markets but not to scale | Being introduced in some niche markets but not to scale | Being introduced in some niche markets but not to scale |
| Augmented reality and new computing technologies | Being introduced in some niche markets but not to scale | Being introduced in some niche markets but not to scale | Being introduced in some niche markets but not to scale | Potential being explored extensively in some markets | Potential being explored extensively in some markets |

Potential being explored extensively in some markets

Being introduced in some niche markets but not to scale

ASEAN= Association of Southeast Asian Nations. ICT = information and communication technology.

Source: Authors.

In exploring this transformation, however, the debate needs to focus not just on technological applications, but also on reshaping mindsets, incentives, policies, and institutions. The implications of these smart digital technologies in realising the environmental sustainability benefits and managing the market risks will depend on the countries' ability to meet the formidable challenges of governance and finance. These challenges loom large in developing countries because natural resources are often poorly managed by the existing institutions and inadequately served by the markets. Success will require institutions that are not only open to new ideas and agile, but also supported by strong regulations when needed. Success will also depend on innovation in finance, with new business models and new investment vehicles that can enable and incentivise technological solutions and be applied at scale. Full-scale adoption also requires investment in continuous assessment of these technologies and learning so that stakeholders can better understand and address the sustainability benefits and social effects of these often disruptive technologies.

Many contributions of integrated ICT, digital, and space technologies to date are centred on fostering productivity, efficiency, and growth. Digital e-commerce platforms may be supported by data mining tools and weak AI, which are useful for identifying behavioural patterns and understanding consumer profiles. Integrated digital systems also have the potential to supply a broader variety of environmental goods and green services such as disaster-related information, which are individually tailored to lower costs, benefitting consumers around the region – across the national boundaries of the AMS. However, the net costs and benefits depend on a number of factors. If societies are not prepared to cope with these technological systems, this could increase inequality, reduce the environmental benefits, and hamper the achievement of the Sustainable Development Goals (SDGs). Table 18.5 summarises the current achievements of the SDGs in AMS.

Several studies (Anbumozhi et al., 2021a, 2021b, 2021c) have indicated the potential of smart technologies when combined with big data and blockchain approaches in promoting green jobs and circular enterprises, non-dangerous safety works, extending environmental protection, and promoting sustainability; and thus could become an accelerator of the 17 SDGs.

## Table 18.5 Progress in Meeting the SDG Targets in AMS, Japan, China, and India

| Country | SDGI | SDG1 | SDG2 | SDG3 | SDG4 | SDG5 | SDG6 | SDG7 | SDG8 | SDG9 | SDG10 | SDG11 | SDG12 | SDG13 | SDG14 | SDG15 | SDG16 | SDG17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Japan | 80.2 | 99.3 | 74.6 | 94.3 | 96.4 | 60.7 | 94.3 | 87.8 | 92.1 | 87.3 | 81.2 | 95.1 | 55.5 | 80.0 | 59.0 | 64.9 | 88.3 | 52.3 |
| Malaysia | 69.7 | 98.2 | 54.1 | 83.1 | 88.1 | 51.2 | 99.0 | 84.1 | 71.2 | 60.8 | 40.7 | 94.5 | 69.7 | 82.4 | 45.9 | 31.6 | 79.0 | 59.9 |
| Thailand | 69.5 | 100.0 | 55.0 | 76.2 | 76.2 | 65.7 | 95.1 | 76.9 | 85.2 | 39.8 | 64.8 | 75.1 | 70.4 | 73.0 | 45.0 | 63.2 | 58.0 | 62.6 |
| Singapore | 69.0 | 98.6 | 71.1 | 93.8 | 92.3 | 68.3 | 88.9 | 90.7 | 95.0 | 85.7 | 37.7 | 92.9 | 43.3 | 48.1 | 21.2 | 26.2 | 89.8 | 28.7 |
| Viet Nam | 67.9 | 99.0 | 62.1 | 74.6 | 81.3 | 76.4 | 90.7 | 72.4 | 60.8 | 24.9 | 65.5 | 66.4 | 71.2 | 73.4 | 51.8 | 46.6 | 65.6 | 71.4 |
| China | 67.1 | 99.5 | 66.8 | 79.5 | 74.1 | 74.8 | 88.2 | 67.7 | 71.9 | 57.7 | 52.4 | 61.6 | 74.8 | 58.7 | 31.1 | 58.5 | 69.1 | 54.5 |
| Philippines | 64.3 | 92.5 | 50.2 | 61.1 | 84.0 | 64.5 | 85.5 | 64.6 | 60.8 | 24.5 | 49.9 | 68.0 | 82.2 | 88.5 | 50.7 | 51.5 | 61.1 | 53.9 |
| Indonesia | 62.9 | 94.6 | 46.9 | 60.7 | 76.2 | 59.3 | 81.6 | 64.8 | 67.7 | 25.4 | 60.2 | 58.7 | 79.3 | 88.5 | 44.5 | 44.2 | 69.9 | 46.5 |
| Lao PDR | 61.4 | 86.1 | 51.4 | 55.8 | 64.2 | 68.3 | 79.3 | 38.1 | 66.0 | 12.9 | 64.7 | 67.4 | 78.8 | 81.8 | – | 51.8 | 63.6 | 52.3 |
| Myanmar | 59.5 | 87.5 | 52.2 | 56.7 | 67.9 | 67.8 | 84.9 | 36.9 | 51.5 | 13.3 | – | 27.7 | 77.6 | 81.6 | 38.4 | 51.3 | 57.6 | 100.0 |
| India | 58.1 | 93.4 | 36.9 | 55.2 | 65.3 | 33.3 | 73.7 | 54.0 | 68.3 | 33.1 | 72.5 | 34.3 | 81.6 | 74.7 | 42.9 | 47.0 | 69.4 | 51.7 |

AMS = ASEAN Member States, ASEAN = Association of Southeast Asian Nations, SDG = Sustainable Development Goal, SDGI = Sustainable Development Goals Index.

Source: Anbumozhi, Kalirajan, and Kimura (2022).

## Challenges in Embracing the Third Unbundling and Smart Digital Technologies for Sustainability Gains

Perceived risks in AMS for the marketability of these technologies are also high, where market-based mechanisms to finance sustainability initiatives are in the early stage of development. Producer and consumer responsibilities are low, with subsidies remaining, and they do not reflect the full costs including environment externalities. Regulatory regimes are also complicated, creating additional uncertainties. These conditions do not provide adequate incentives for private investment, resulting in different levels of readiness in terms of sustainability, such as the circular economy (Table 18.6).

**Table 18.6 Enablers and the Readiness Rating of AMS for Integrating Smart Technologies into the Circular Economy**

| Country | Higher education and training | Goods market efficiency | Labour market efficiency | Financial market development | Technological readiness | Market size | Overall rating |
|---|---|---|---|---|---|---|---|
| Cambodia | 2.8 | 4.2 | 4.5 | 3.9 | 3.0 | 3.0 | 3.6 |
| Indonesia | 4.5 | 4.4 | 3.7 | 4.2 | 3.5 | 5.7 | 4.3 |
| Lao PDR | 3.2 | 4.3 | 4.5 | 3.8 | 2.8 | 2.9 | 3.6 |
| Malaysia | 5.0 | 5.4 | 4.9 | 5.2 | 4.6 | 5.0 | 5.0 |
| Myanmar | 2.5 | 3.6 | 4.2 | 2.4 | 2.2 | 4.2 | 3.2 |
| Philippines | 4.5 | 4.2 | 4.1 | 4.2 | 3.9 | 4.9 | 4.3 |
| Singapore | 6.2 | 5.7 | 5.7 | 5.6 | 6.2 | 4.8 | 5.7 |
| Thailand | 4.6 | 4.7 | 4.2 | 4.4 | 4.2 | 5.2 | 4.6 |
| Viet Nam | 3.8 | 4.2 | 4.4 | 3.7 | 3.3 | 4.8 | 4.0 |

AMS = Association of Southeast Asian Nations Member States.

Source: Viswanathan and Anbumozhi (2018).

Despite the potential of smart and digital technologies, they pose various risks. As can be seen in Table 18.6, the application of new ICT to preserve the environment and tackle vulnerability seems to be imminent, and data will be the foundation of the revolution as all the digital technologies will be built upon it. Individuals, companies, and governments will increasingly rely on the ability to move, process, and store data through ASEAN to provide the green products and services necessary to reap sustainability benefits.

If data become a prized commodity, the important question is who owns the data and has access to which piece of data. Disconnected data platforms and competing networks of data provision and management may also emerge, using their own data protocols and standards. Common protocols and standards need to be created at the regional level in conformation with evolving global standards. If environmental preservation and resilience is a public good, who could become the curators of regional environmental information? How can private companies avoid being monopolies, holding environmental and social data for their own profit, rather than being platforms for promoting widespread and open innovation. These questions will need to be addressed by communities, countries, and ASEAN and East Asia as a whole.

Nevertheless, these technological systems also have the potential to disrupt the old institutional and governance systems built around the three pillars of the ASEAN Community – the ASEAN Economic Community, ASEAN Socio-Cultural Community, and ASEAN Political–Security Community. For example, a rich new stream of information about deforestation and endangered species could help improve the sustainable management of forests. Such data could also radically improve the transparency and traceability of the haze problem, providing new tools in the fight against illegal deforestation. However, if a regional organisation that hosted this data was hacked, these same data innovations could enable even more illegal deforestation or hunting of endangered species.

However, markets need to evolve to meet the specific needs of these new technologies. The phenomenon of leapfrogging implies jumping to a new set of highly efficient technologies and services – skipping the old, inefficient, and polluting ones. But if leapfrogging is to become a dominant pattern, rapid institutional innovations are needed to create the business practices and policy frameworks to make that happen, both at the systemic level – i.e. new business models, market design, regulation and policy instruments, and financing – and at the operational level – consumer engagement, supply-side management, and demand response. Further, flexibility is needed in policy design, as the end points of absorbing these technologies will differ in countries, sectors, and communities; and the pathways to get there could vary.

## Conclusion

As Asian governments are slowly turning their focus from raw GDP-driven measurement of economic growth towards well-being criteria of sustainable and inclusive growth, the demand for new technologies that provide environmental solutions is increasing. The potential to create transformative changes is immense, but realising the opportunities will not happen automatically. Proactive and collaborative processes with policymakers, technology champions, academia, and international institutions will be required at the regional level, so that commonly agreed national policies and regional protocols are developed to bring maximised sustainability benefits and strengthen resilience.

Governments and important stakeholders, such as international organisations, academia, and business, each have roles to play. When it comes to the application of new digital technologies, markets alone will not offer adequate incentives in the early stages of technology adoption. Most AMS are low- and middle-income countries, and governments must find ways to arrest the deterioration of the environment with current regulations that must also find a way to keep up with the rapid penetration of these technological systems. That means creating room for experimentation by allowing states and communities to take advantage of the new technological potential to find better or alternative ways of managing environmental challenges. It means reforming long-established regulatory regimes to take advantage of the digital tools becoming available for better understanding and control of environmental risks and resilience challenges.

Technology companies and entrepreneurs have a central role to play and create business models that can support the development and global application of innovations for environmental sustainability and resilience. Whether for fleets of satellites and drones that can provide vital new data streams, or for algorithms and computer applications that can translate those streams into planning tools for better natural resources management, pollution control, and climate resilience, new business models are needed. Such business models provide a viable proposition for governments and communities to consider them as public goods.

The following collaborative frameworks will be particularly important as part of the Comprehensive Asian Development Plan (CADP) 3.0:

- Dialogues and partnerships that bring Industry 4.0/digital/smart technology developers and providers together with environmental experts to co-develop these innovations and ensure that they are developed for public goods, i.e. sustainability, while minimising common cybersecurity risks.
- Innovative investment platforms, financing structures, and business models that can accelerate the scaling of promising eco-innovations that could be supported by a combination of smart technologies, regardless of whether they have a clear commercial proposition or less profitable sustainability benefits.
- Partnership with other and international institutions to enable the development of common and agile institutions and governance systems, including the championing of common policy principles for managing new technologies and specific data protocols and transparency mechanisms.
- Regularly reviewing and, where appropriate, revising the emerging legislative and regulatory framework to clarify and explicitly articulate the precise roles of new types of technologies that increase environmental benefits and strengthen the resilience capability of individual households and vulnerable communities.

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