RSIS COMMENTARY

22 December 2025

SpaceAI for Sustainability: Opportunities and Challenges for Southeast Asia

Karryl Kim Sagun Trajano and Iuna Tsyrulneva

PONDER THE IMPROBABLE

RSIS S. RAJARATNAM SCHOOL OF INTERNATIONAL STUDIES
Nanyang Technological University, Singapore

Ponder the Improbable since 1996

RSIS COMMENTARY

www.rsis.edu.sg
No. 246 – 22 December 2025

SpaceAI for Sustainability: Opportunities and Challenges for Southeast Asia

By Karryl Kim Sagun Trajano and Iuna Tsyrulneva

SYNOPSIS

From forecasting extreme weather to preventing orbital collisions, SpaceAI – the convergence of space technologies with artificial intelligence – can transform sustainability efforts on Earth and in space. In Southeast Asia, regional cooperation through shared missions, cross-border AI development, and aligned policies will be key to building a future-ready SpaceAI ecosystem.

COMMENTARY

Artificial intelligence (AI) has been increasingly scrutinised for its environmental costs, including electronic waste, greenhouse gas emissions, and high water consumption, as well as its reliance on unsustainably-sourced rare-earth minerals. While it poses ecological challenges, it also holds significant potential to advance sustainability when designed with energy and resource efficiency in mind. There is much to be harnessed in the technology for the common good. One promising frontier lies in the convergence of AI and space technologies, a field known as SpaceAI, which offers novel ways to mitigate environmental risks on Earth and in space.

Expanding the Boundaries of Sustainability

Sustainability is often conceived within the context of Earth's challenges, including climate change, deforestation, waste management, and the conservation of terrestrial and marine resources. Even the United Nations' Sustainable Development Goals (SDGs) 14 and 15 reinforce this orientation, focusing on the sustainable use and restoration of ecosystems and on combating deforestation, land degradation, and biodiversity loss on land and at sea.

However, humankind's footprint extends beyond Earth. The proliferation of satellites and orbital activity has intensified concerns about debris accumulation (the build-up of defunct spacecraft, fragments, and collision leftovers), orbital congestion (crowded traffic lanes in space that increase collision risks), and the long-term viability of space infrastructure (the ability to maintain the longevity and safe operation of satellites and space systems far into the future). These challenges parallel terrestrial and marine issues of overconsumption and pollution, underscoring that sustainability is now both planetary and orbital.

SpaceAI enables on-board autonomy, allowing satellites to process data directly in space rather than sending it back to Earth. This reduces delays and prevents overcrowding of communication bandwidth. AI-driven fault detection, isolation, and recovery (FDIR) systems act like an automated safety net, spotting problems early, containing them, and helping fix them, thereby improving spacecraft reliability and extending mission lifespans, including by supporting on-orbit servicing.

Machine learning algorithms also strengthen space situational awareness (SSA), the system that tracks objects in orbit. It can forecast debris paths and potential collisions up to seven days in advance. Onboard AI can then automatically calculate and trigger avoidance manoeuvres, identify the best timing for debris-removal missions, and map safe "corridors" for satellite launches. AI further supports orbital manoeuvres by optimising fuel use, allowing spacecraft to change orbits more efficiently and remain operational for longer.

On Earth, AI-powered remote sensing enhances weather observation and prediction, deforestation mapping, disaster response, water quality, and waste management analytics. In essence, SpaceAI serves as a technological bridge between environmental stewardship on Earth and the responsible utilisation of space.

Singapore's Emerging Role in the SpaceAI Ecosystem

Singapore has begun exploring the intersection of space and AI across its public, private, and academic sectors. Since the establishment of the public sector's Office for Space Technology and Industry (OSTIn) in 2013, it has worked to develop a coordinated ecosystem that links space players across government, universities, and industry. This integrated approach, aligned with Singapore's broader Smart Nation initiative, has laid the foundation for advancing capabilities in satellite research, imaging, and autonomous systems, contributing to the development of AI-powered space technologies.

Academic institutions such as Nanyang Technological University's (NTU) Satellite Research Centre (SaRC) have been advancing research in on-board AI processing, data fusion, and edge computing for nanosatellites. Complementing this, NTU's Earth Observatory of Singapore - Remote Sensing Laboratory (EOS-RS) and the National University of Singapore's (NUS) Centre for Remote Imaging, Sensing and Processing (CRISP) employ advanced remote sensing technologies to monitor and map hazards, disasters, environmental crises, sea-level rise, and the broader impacts of climate change.

For example, the NUS-built Galassia-5 satellite will test onboard AI to detect ships at sea and send only key information back to the ground, shifting data processing from the ground to space for faster, more efficient operations. Researchers validate preliminary findings by integrating data from news reports, aerial imagery, and ground-level videos across selected regions. These underscore Singapore's academic activities in harnessing space-based and AI-enabled technologies.

Meanwhile, start-ups and established firms in the private sector have begun experimenting with AI-enabled geospatial analytics, foundation models, autonomous mission-planning tools, and sustainable small-satellite design, contributing to a nascent yet dynamic innovation landscape. ST Engineering Geo-Insights uses AI to clean and analyse satellite images, supporting maritime, environmental, and agricultural monitoring, including tracking deforestation and water quality. Singapore-based Arkadiah uses AI and satellite data to create digital maps of landscapes, helping estimate carbon and support conservation efforts across Southeast Asia.

Singapore's equatorial location also offers unique advantages for Earth observation, enabling the collection of high-frequency data on tropical climate dynamics, maritime traffic, and forest health. Such datasets are particularly relevant to Southeast Asia's sustainability priorities.

By developing the capacity to process and interpret this "equatorial data" through AI, Singapore can contribute meaningfully to regional environmental resilience and collective knowledge-building, even as it continues to learn from and collaborate with partners with longer-standing space capabilities. LeoLabs partnered with ST Engineering Geo-Insights to set up a Space Situation Awareness Centre in Singapore for the Asia-Pacific. Singapore likewise supports SpaceAI cybersecurity with a SpeQtral and SES ground station for Asia-Europe quantum missions, while Space Armour builds AI-powered, secure platforms for autonomous satellite operations.

Taken together, these developments point to Singapore's small but emerging role in shaping the regional SpaceAI ecosystem, where its strengths in coordination, innovation, and collaboration can complement broader efforts toward a more sustainable space in Southeast Asia.

Opportunities for Regional Cooperation

Southeast Asia's space landscape is diversifying, with established national agencies in Indonesia, Malaysia, the Philippines, and Vietnam, as well as emerging efforts in other countries.

Indonesia's LAPAN Automatic Identification System, led by its National Research and Innovation Agency (BRIN) with multi-agency support, combines geospatial analytics and image processing for maritime surveillance and investigations. Malaysia's MySpatial partnered with EarthDaily Analytics to deliver AI-driven Earth Observation for agriculture, the environment, and maritime intelligence. The

Philippine Space Agency (PhilSA) collaborates with local universities to develop onboard Image Classification Units.

However, programmes remain fragmented, with limited mechanisms for data sharing, standardisation, and regional tasking coordination. Given that environmental challenges such as haze pollution, illegal fishing, and extreme weather are inherently transboundary, a regional SpaceAI framework could enhance collective resilience. Importantly, the building blocks already exist: Thailand's Geo-Informatics and Space Technology Development Agency uses THEOS-2 for high-resolution Earth Observation and capacity building, while PhilSA's DATOS applies AI to satellite imagery for faster landslide detection.

Joint AI-enabled satellite missions and shared processing infrastructure could harmonise regional monitoring capabilities. For instance, federated learning models, in which AI algorithms are trained across distributed datasets without moving the data itself, could enable ASEAN states to collaborate on sensitive Earth observation data while maintaining national sovereignty.

Shared tasking, powered by a defined regional standard, would enable partners to develop and upload vetted models designed for cloud filtering and ship or fire detection to processors hosted on participating spacecrafts. Pilot projects using quantum technology originating from Singapore can provide a path to protect sensitive multi-country data flows essential for SpaceAI collaboration. Such initiatives would align with ASEAN's digital integration and sustainable development agendas and reinforce regional strategic autonomy in space data governance.

Bridging the Talent and Policy Gaps

Despite these opportunities, Southeast Asia faces two key constraints: a talent gap and a policy gap. The convergence of AI and space requires interdisciplinary expertise spanning machine learning, orbital mechanics, systems engineering, and regulatory governance. While Singapore's National AI Strategy 2.0 has begun cultivating advanced digital skills, a complementary National Space Strategy could further integrate space systems training and create cross-disciplinary pathways, enabling AI engineers to acquire space domain knowledge, and space scientists to learn computational methods.

Policy frameworks likewise need alignment. Space activities in the region are regulated under fragmented national frameworks that often lag behind emerging technologies such as on-orbit servicing, autonomous spacecraft, and AI-based decision systems. Developing coherent, ethically grounded governance standards covering data transparency, algorithmic accountability, and sustainable launch practices will be essential to ensure that SpaceAI grows responsibly and sustainably.

Towards a Sustainable Space Future

The convergence of AI and space technologies presents Southeast Asia with a unique opportunity to participate in sustainable innovation. Singapore's model of ecosystem orchestration, combining strategic planning, public-private partnerships, and academic excellence, demonstrates how small states and relatively newer space players can participate through coordination rather than scale.

To sustain momentum, the region must invest in SpaceAI research, talent pipelines through shared capacity-building measures, and multilateral collaboration. As orbital congestion builds up further and Earth's environmental challenges deepen, embedding sustainability into every layer of SpaceAI development, be it technological, institutional, or strategic, will be critical.

For Southeast Asia, SpaceAI offers more than technological promise. It presents an opportunity to help shape a sustainable model of innovation grounded in cooperation. How the region chooses to harness this convergence will help determine whether space and AI become extensions of the Earth's problems or a proving ground for its solutions.

Karryl Kim Sagun Trajano is a Research Fellow at Future Issues and Technology (FIT), S. Rajaratnam School of International Studies (RSIS), Nanyang Technological University (NTU), Singapore. Iuna Tsyrulneva is a Research Fellow at NTU's Earth Observatory of Singapore (EOS).

Please share this publication with your friends. They can subscribe to RSIS publications by scanning the QR Code below.