Developing the SDG Satellites for Measuring and Evaluating Indicators of SDGs

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Key messages

The successful launch and operationalization of the first Sustainable Development Goals Satellite (SDGSAT-1) provides new opportunities for monitoring and measuring SDG indicators and facilitates the implementation of the 2030 Agenda for Sustainable Development. SDGSAT-1 is also the first in a series of satellites to be launched as part of an Earth observation constellation for SDGs. To benefit from these developments, international organizations and developing nations should empower policy makers to diversify data sources and develop localization programs to realize the full potential of digitization. Researchers should focus on interoperability and data fusion studies to create new opportunities for data products and services for SDGs and the international community should utilize SDGSAT-1 and other data sources to fuel community-driven movement toward sustainability.

The expanding digital infrastructure and growing importance of AI and big data provide unique opportunities to address global challenges such as food security, climate change, and sustainable development. The 2030 Agenda for Sustainable Development (2030 Agenda) provides a globally accepted framework with concrete goals and targets, guiding actions, and a means to track and implement relevant national and regional actions ensuring progress across economic, environmental, and social dimensions [1]. However, uneven development across different nations, varying levels of technical capabilities and access to economic resources have limited wider adoption of rapidly developing digital resources for different public policy and decision support systems, especially for Sustainable Development Goals (SDGs). Other challenges, such as geopolitics and the impacts of the COVID-19 pandemic have also complicated implementation efforts. Collectively, these challenges have in many cases even limited monitoring of progress towards SDGs due to lack of data, as many developing countries sometimes also lack basic health, social, and economic data, exacerbated by lack of insufficient research methods and resources [2–4]. Challenges in governance, capacity, and a lack of comprehensive engagement of stakeholders all interplay and limit informed policies that could ensure sustainability.

An important data resource, in terms of monitoring human development, natural or anthropogenic changes, and the natural environment, has been the development and growth of Earth observation platforms periodically recording transformations in near-real time on the ground and even by air over the past several decades. Therefore, these "space tools" have been recognized as highly useful toward the 2030 Agenda through a resolution adopted in 2021 by the UN General Assembly [5]. Earth observation data from satellites provide spatial attributes relevant to understanding and solving sustainability challenges and additionally provide new opportunities to facilitate data-driven policy and decision-making support [6,7]. Therefore, to better facilitate data collection and improve global data coverage for SDGs, the International Research Center of Big Data for Sustainable Development Goals (CBAS) developed and launched the Sustainable Development Goals Science Satellite 1 (SDGSAT-1) on 5 November 2021 with design specifications meant to monitor SDGs [8]. Data from SDGSAT-1 will not only serve the data needs of UN Member States but also research and scientific applications. SDGSAT-1 is the first in a series of satellites that will form a constellation of SDG-specific satellites to provide a reliable stream of information relevant to achieving the SDGs.

SDGSAT-1 provides a glimpse of upcoming data resources for SDGs in support of the 2030 Agenda. It is equipped with three advanced sensors: a thermal infrared spectrometer, glimmer imager, and multispectral imager, which can be used to acquire multitype, high-precision data for a variety of SDG applications, especially SDG indicators representing human-nature interactions.

SDGSAT-1 to Support UN SDGs

The SDGSAT-1 data is useful for different SDG indicators, such as population (SDG 1), agriculture (SDG 2), well-being estimation (SDG 3), economic livelihoods (SDG 4), water quality (SDG 6), informal settlements (SDG 11), climate-related hazards and natural disasters (SDG 13), and coastal environments and terrestrial ecosystems (SDG 14, 15) [9,10].

The satellite's thermal infrared spectrometer can detect temperature differences with an accuracy of NEDT (noise equivalent differential temperature) less than 0.041 K @ 300 K at a spatial resolution of 30 m, which will be very useful for detecting thermal radiation intensity, temperature field distribution, water temperature, and heat sources. It will therefore be helpful for observing glacial variations, ecosystem changes, and port activity.

The multispectral imager is useful for monitoring coastal and land environments, urban area function, artificial construction, and the intensity and concentration of human activity. It is also equipped with two deep blue bands to detect water composition in a variety of water bodies, as well as a red edge band to monitor vegetation growth on land.

The glimmer imager in SDGSAT-1 is innovative in its design by adding color bands in addition to a panchromatic band, a feature not available in other spaceborne night-time light sensors. The spatial resolution of the color bands is 40 m, and that of the panchromatic band is 10 m. The glimmer imager will be useful for picking up low-light data for monitoring urban populations and human activity during night-time, facilitating spatial estimation of social and economic development, assessing power consumption, and detecting snow and ice during polar nights.

The multi-mode capacity of SDGSAT-1 allows synergetic operation of its three sensors around the clock. This mode allows the thermal infrared spectrometer to work simultaneously with the multispectral imager during daylight monitoring, the glimmer imager during night-time monitoring, and the thermal infrared spectrometer operating day and night, in addition to independent operational tasks. This improves consistency of information on objects under observation from different sensors and allows a more comprehensive analysis. The data from SDGSAT-1 also provides an opportunity to compare changes in spectral reposes of objects between day and night by comparing data from the multispectral and glimmer imagers [8,11].

CBAS has made the data from SDGSAT-1 available free of charge to the scientific community around the world via the SDGSAT-1 Open Science Program initiated in September 2022. This open data initiative will support Chinese commitments made during the High-level Dialogue on Global Development in June 2022, which acknowledged the global challenges for sustainable development and recognized the need to conduct joint efforts to build an international consensus on development in support of the 2030 Agenda.

SDG Satellite Constellation

CBAS will also lead the effort to develop the SDG satellite constellation announced by China to aid all countries in the collection and utilization of SDG data and information. A constellation would enhance coverage and create a steady stream of reliable Earth observation data to mitigate global data gaps on SDGs. Building upon SDGSAT-1, the SDG satellite constellation is expected to:

(1) Facilitate and incentivize data analytics and technology companies to provide data-driven business strategies and solutions on SDG-related challenges for those operating in developing countries [12].

(2) Empower cloud-based data analysis systems to strengthen science-technology-policy frameworks within local governance structures in developing countries [13]. Based on this data, public digital SDG products could help bridge the global digital information divide [14].

(3) Provide spatiotemporal attributes for global processes and systems that can prove valuable for data interoperability with other sources of big data to enable a more comprehensive evaluation of complex processes [15].

(4) Provide valuable data about Earth systems for environment-related SDGs, improving geographic coverage and providing internationally comparable country-level datasets [3,13,16].

The satellite constellation aims to "Enhance space-derived economic benefits and strengthen the role of the space sector as a major driver of sustainable development", which is the first overarching objective of the Space2030 Agenda. It will also support the growing demand for spatial information, improve capacity for Earth observation as a digital solution for SDGs, and provide new knowledge and data for research and development.

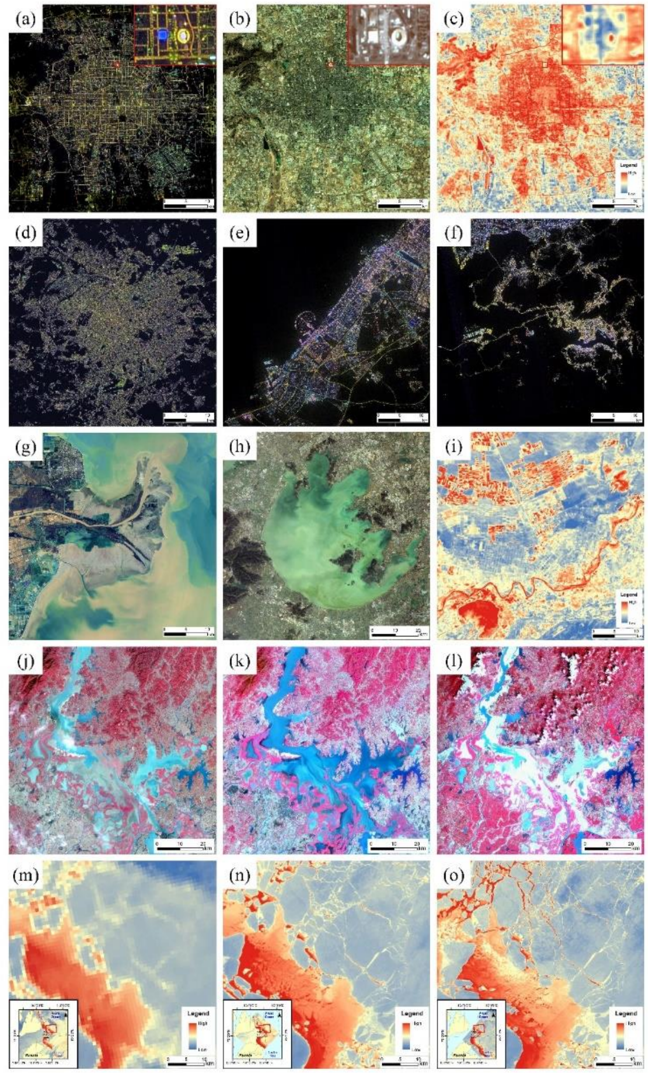

Figure 1. Imagery captured by SDGSAT-1 [8]. Glimmer (a), multispectral (b), and thermal infrared (c) images of Beijing to demonstrate the synergetic observation of SDGSAT-1 for the same object. Glimmer images of Paris (d), Dubai (e), and Hong Kong (f) showing the innovative glimmer imager and its capability for global data collection. Multispectral images of the Yellow River Estuary (g) and Lake Taihu (h) in China to exhibit the potential applications for SDG 6 in different types of water bodies. Thermal infrared images of Beijing (c) and the Aksu region (i) of China, also in different scenarios, namely supercity and natural environments. Multispectral images of Lake Poyang in China in November 2021 (j), April 2022 (k), and September (l) 2022 illustrating water body changes in different seasons recorded by SDGSAT-1. Thermal infrared images near Maly Taymyr Island in the Russian Arctic, captured by MODIS (m), Landsat 9 (n), and SDGSAT-1 (o), respectively, on 27 April 2022 with an interval of only several hours to compare their performance in environmental object detection.

Data source: SDGSAT-1

Policy recommendations / conclusions

The unique characteristics of satellite technology—macro-level, frequent, objective data acquisition—endow it with strong capabilities for monitoring and evaluating SDG indicators. Indicators of SDG 2, 6, 11, 13, 14, and 15 are related to large-scale features on Earth's surface with a high rate of change, making them especially suitable for monitoring with satellites.

Considering the rapid development of Earth observation technology, the growing number of satellite platforms, the development of new Earth observation constellations, and the expanding volume of Earth observation data, developing nations and international organizations should consider following these key policy recommendations:

- The Global Development Initiative and the UN Technology Facilitation Mechanism (TFM) should be used as frameworks to improve the science-policy interface to encourage governments at all levels in developing nations to take advantage of Earth observation satellites. A strength of the SDGSAT-1 program was its development under these frameworks, enabling initiatives such as the SDGSAT Open Science Program. The UN, governments, and international organizations should consider similar mechanisms for global satellite data sharing, promoting SDG assessment applications, and quickly constructing virtual constellations of SDG satellites.
- The UN and other international organizations should achieve the maximum potential of these data resources by supporting localization programs that empower individuals to gain knowledge, develop skills, and utilize these resources to develop local solutions to local challenges. Organizations like CBAS should work closely with these UN programs to facilitate data access and processing.
- Researchers should work to target interoperability between different Earth observation platforms within a big data framework. Interoperability and data fusion research can open new opportunities for continuous streams of viable information, improving data resolutions necessary for monitoring and decision support for sustainable development.
- For more collaborative international engagements, data from SDGSAT-1 and other Earth observations systems provide important foundational data to fuel community-driven movement towards sustainability. For example, CBAS' proposed community-driven open-source framework for digital public goods for SDGs can help reduce and fill in gaps in capacity for producing digital public goods for SDGs. This approach facilitates localization programs and engages a talented volunteer community to share ideas and publish digital products by utilizing open data and computation resources, under necessary QA/QC measures and political oversight with UN guidance. The UN and other organizations should therefore promote a community-driven 'science-policy-society' monitoring framework for SDGs built upon open data and resources.

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