

Recent Advances of the SDGSAT-1 for Supporting Global SDG Monitoring and Evaluation*

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Abstract As a dedicated scientific satellite tailored to advance the implementation of the United Nations 2030 Agenda for Sustainable Development (2030 Agenda), the Sustainable Development Goals Satellite 1 (SDGSAT-1) has entered its fifth year of in-orbit operation. This satellite has witnessed a rapid diversification in its research applications. The satellite's data have been used by more than 116 countries, and over 220 peer-reviewed papers have been published. Such remarkable research growth is attributable to the high-quality data products derived from SDGSAT-1's technological innovations, alongside its open data access policy and sustainably maintained operational status underpinned by the SDGSAT-1 Open Science Program. This paper presents a state-of-the-art review of the mission's research progress over the past two years and elaborates on the future development prospects for ongoing global SDG monitoring and assessment.

Key words SDGSAT-1, Earth observation, Sustainable Development Goals (SDGs), Remote sensing

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1 Introduction

Over the past decade, global communities have strived to achieve the 17 Sustainable Development Goals (SDGs) set forth in the United Nations (UN) 2030 Agenda for Sustainable Development (2030 Agenda). Collectively, these 17 SDGs, along with their 169 targets and 234 indicators, provide a comprehensive quantitative framework for measuring progress in peace and prosperity for people and the planet. However, the implementation of this optimistic vision faces challenges that were perhaps unforeseen, as the world has been drawn into intensifying climate change, unexpected natural disasters, and economic development uncertainty. These challenges have led to stagnation, uneven progress, and even

regression in sustainable development in some regions and sectors, despite overall advancement^[1]. Meanwhile, advances in science and technology, including artificial intelligence, space technology, and big data, continue to deliver new platforms and methodologies that are revolutionizing both the evaluation and realization of the SDGs by addressing limitations in data availability and resolution.

Earth Observation (EO) has emerged as a powerful and indispensable tool for advancing Sustainable Development Goal (SDG) evaluation^[2], owing to its unique capacity to acquire objective datasets concerning environmental conditions and socioeconomic dynamics. The Sustainable Development Goals Science Satellite 1 (SDGSAT-1) stands as a frontier of EO satellites dedicated

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to SDG-related applications. Developed by the International Research Center of Big Data for Sustainable Development Goals (CBAS), the satellite is specifically designed to characterize human-nature interactions. It is equipped with three advanced EO payloads, namely the Glimmer Imager (GLI), the Thermal Infrared Spectrometer (TIS), and the Multispectral Imager (MSI). All sensors feature a consistent swath width of 300 km while possessing distinct complementary advantages for diversified observation scenarios.

The GLI is dedicated to capturing spatiotemporal dynamics of terrestrial Artificial Light at Night (ALAN). It integrates RGB bands at 40 m spatial resolution and a 10 m panchromatic band, delivering unprecedented spectral and spatial resolution among all publicly available spaceborne EO datasets. The TIS enables accurate retrieval of land surface temperature at 30 m resolution, achieving the finest spatial resolution currently available for civilian satellite missions. Equipped with seven multispectral bands, the MSI includes two deep-blue bands and one red-edge band, which provide innovative insights into water quality monitoring and vegetation ecological research, respectively. Beyond independent operation of the three payloads, SDGSAT-1 supports synergistic observation modes: coordinated TIS-MSI imaging is performed in daytime, while joint TIS-GLI observation is conducted at night, supplying multi-dimensional complementary information for comprehensive target monitoring and analysis.

From late 2021 to mid-2024, SDGSAT-1 achieved initial remarkable progress in supporting SDG-related research, yielding more than 70 academic publications and attracting data users across 88 countries^[3]. Over the past two years (2024–2026), the mission has gained further prominent momentum in international applications. Its research themes, scientific outputs and study regions have undergone extensive diversification. To date, the cumulative number of peer-reviewed publications has exceeded 220, and registered users of the SDGSAT-1 Open Science Program now span 116 countries worldwide.

More specifically, SDGSAT-1 relevant has covered 22 specific SDG targets across 11 SDGs^[4,5], including SDG 1 (No Poverty), SDG 2 (Zero Hunger), SDG 3 (Good Health and Well-being), SDG 6 (Clean Water and

Sanitation), SDG 7 (Affordable and Clean Energy), SDG 9 (Industry, Innovation and Infrastructure), SDG 11 (Sustainable Cities and Communities), SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action), SDG 14 (Life Below Water), and SDG 15 (Life on Land). Beyond the continued application of single-sensor datasets, recent studies have increasingly exploited multi-sensor synergistic observations. Furthermore, researchers have integrated SDGSAT-1 data with other widely adopted EO datasets to enhance temporal and spectral observation capabilities as well as socioeconomic data sources.

This paper reviews the latest advances of the SDGSAT-1 mission and its data application developments, with a particular emphasis on recent international studies, multi-sensor synergies, multi-satellite collaborative research, and advances in data processing methodologies. The remainder of this paper is organized as follows. Section 2 elaborates on the core technical strengths of SDGSAT-1 and recent progress in data quality improvement. Section 3 discusses the expanding application scope of SDGSAT-1 data products and their global influence. Section 4 outlines future prospects regarding sustainable development satellite constellations and potential international cooperation frameworks. Finally, Section 5 concludes the paper with summary remarks.

2 Evolution of SDGSAT-1 Operation

2.1 SDGSAT-1 Technical Specification

SDGSAT-1 has maintained stable operation for more than four years, and all three onboard sensors (technical parameters listed in Table 1) are expected to continue delivering high quality data sources for years to come. Figure 1 shows recent images of Beijing captured by SDGSAT-1, demonstrating the satellite's capability to monitor thermal environment, nighttime light distribution, and ground surface layout in the selected research area.

The design of SDGSAT-1 centered on the demands of monitoring human-nature interactions, which reflect the interconnected nature of the SDG global indicator framework. To provide global high-resolution imaging capability, SDGSAT-1 operates in a sun-synchronous orbit at an altitude of 505 km with an inclination angle

Table 1 Technical parameters of SDGSAT-1 sensors

Type	Parameter	Specification
Multispectral imager	Swath width	300 km
	Spatial resolution	10 m
	Designed radiometric accuracy	Relative: $\leq 2\%$ Absolute: $\leq 5\%$
	Bands and central wavelengths	Band 1 (deep blue): 400.63 nm Band 2 (deep blue): 438.47 nm Band 3 (blue): 495.10 nm Band 4 (green): 553.23 nm Band 5 (red): 656.75 nm Band 6 (red edge): 776.12 nm Band 7 (near-infrared): 854.02 nm
Thermal infrared spectrometer	Swath width	300 km
	Spatial resolution	30 m
	Designed radiometric accuracy	Relative: $\leq 5\%$ Absolute: $\leq 1\text{ K}@300\text{ K}$
	Bands and central wavelengths	Band 1: 9.35 μm Band 2: 10.73 μm Band 3: 11.72 μm
Glimmer imager	Swath width	300 km
	Spatial resolution	Panchromatic: 10 m, RGB: 40 m
	Designed radiometric accuracy	Relative: $\leq 2\%$ Absolute: $\leq 5\%$
	Bands and central wavelengths	Blue band: 478.87 nm Green band: 561.20 nm Red band: 734.25 nm Panchromatic band: 680.72 nm

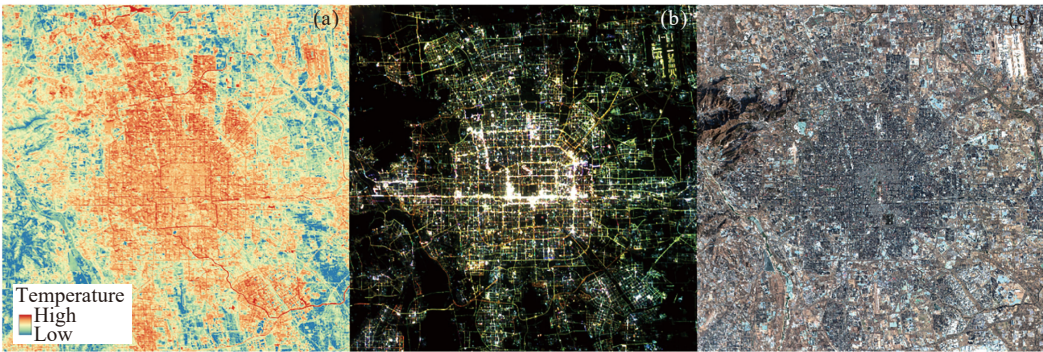


Fig. 1 Images of central Beijing captured by SDGSAT-1. (a) Nighttime band 2 TIS image, captured on 11 March 2026. (b) Nighttime RGB-composite GLI image, captured on 11 March 2026. (c) Daytime RGB-composite MSI image, captured on 2 February 2026

of 97.5° (Table 2), achieving a revisit period of 11 days. Its descending and ascending nodes occur at 09:30 AM and 09:30 PM local time, respectively, creating optimal conditions for monitoring daytime Earth surfaces and nighttime artificial light. The sun is at a moderate alti-

tude when MSI data are collected, while GLI operates during the peak of nighttime human activity.

2.2 Data Quality Evaluation and Improvements

Post-launch calibrations of GLI^[6], TIS^[7] and MSI^[8] have built the foundations for scientific applications of

Table 2 Orbit parameters of SDGSAT-1

Parameter	Specification
Type	Sun-synchronous orbit
Orbit period/min	90
Revisit period/d	11
Altitude/km	505
Inclination angle/(°)	97.5

SDGSAT-1 data. From mid-2024 onwards, continuous efforts have been made to introduce data enhancement methods, data quality evaluations, and tailored spectral indices.

Regarding the GLI, researchers have established procedures to improve both radiometric and geometric accuracy. Tan *et al.*^[9] and Yin *et al.*^[10] have formulated a deep learning-based method and an automatic registration algorithm, respectively, to correct misalignment issues present in GLI images. Zhang *et al.*^[11] have experimented with a radiative transfer model to perform atmospheric correction for GLI, while Wang *et al.*^[12] have constructed a novel image reconstruction method to fill the GLI observation gap caused by the cloud cover. Furthermore, GLI-based spectral indices^[13,14] have been developed and validated for the light source classification.

For the TIS, a series of recent works^[15–18] have tested and proven its ability to accurately derive Land Surface Temperature (LST) and emissivity, while cross-calibrations between TIS and other EO thermal infrared data sources, including Landsat 9 TIRS-2^[19] and FY-4A AGRI^[20], have yielded results that indicate reliable data quality.

Evaluation of the MSI's on-orbit radiometric performance^[21,22] has demonstrated overall satisfactory long-term stability and signal-to-noise ratio. Additionally, the sensor-specific tasseled cap transformation of the MSI^[23] has been developed, with initial applications in ecological monitoring^[24].

2.3 Open Science Data Services

Open data sources are the cornerstone for addressing the data availability issues faced by SDG monitoring. Not only do they reduce the burden of data accessibility, but research methodologies and models developed using open data can also be better validated, applied, and dis-

seminated. Data products from SDGSAT-1 are openly shared through the SDGSAT-1 Open Science Program^{*}, initiated by CBAS. After operation for more than four years, this program has witnessed steady expansion and diversification of its user base. Since the last COSPAR report^[3], the total number of data users has more than doubled, from 1500 in 2024 to over 3500 in early 2026. User backgrounds include researchers at universities and research institutes, as well as analysts and policy consultants in government and UN organizations. Furthermore, as a result of the reliable operation of the satellite, the total number of archived SDGSAT-1 images has reached 510000, offering global coverage. In addition to the access portal for archived data, the Open Science Program offers users the option to upload their research target locations and desired time windows, allowing them to obtain tailored data products.

Furthermore, CBAS has organized international SDGSAT-1 data processing and application training sessions. From 2024 to 2026, SDGSAT-1 specialists offered free in-person or online training to participants from Kenya, Small Island Developing States, and other developing countries. In the future, CBAS will continue to build capacity based on SDGSAT-1, its potential successor satellites and other infrastructure.

3 Advances in SDGSAT-1 Applications

In the past two years, advances in SDGSAT-1 applications have shown a tendency toward multi-sensor, multi-satellite, and international collaboration. From the launch of SDGSAT-1 in November 2021 to mid-2024, fewer than 3% of SDGSAT-1 publications utilized more than one SDGSAT-1 sensor, whereas from mid-2024 to

* <https://www.sdgsat.ac.cn/>

early 2026, nearly 10% of papers published in this period have applied multi-sensor synergistic observations. The geographical scope of research has also expanded well beyond China in the past two years, most notably in Europe and in countries across South-Southeast Asia and Africa. Additionally, SDGSAT-1 is recognized as complementary to well-applied EO data sources, such as Sentinel-2, the Landsat series, and Visible Infrared Imaging Radiometer Suite (VIIRS) onboard the Suomi National Polar-orbiting Partnership (NPP) satellite, achieving results with improved resolution and accuracy across various fields. The following subsections will introduce the progress of SDGSAT-1 applications in these three directions in detail.

3.1 Multi-sensor Applications

One of the most distinctive features of SDGSAT-1 is its ability to depict research targets in both the thermal and optical domains. For GLI-TIS synergistic observation, the application focuses on the detection of human activities. In a marine context, Qiu *et al.*^[25] and Zhang *et al.*^[26] have utilized this combination to study light and heat generated by offshore oil and gas platforms, while Zhang *et al.*^[27] have fused the GLI and TIS data for ship detection. For the research on the urban thermal environment, Ye *et al.*^[28] and Wang *et al.*^[29] have applied TIS and GLI to investigate the correlation between urban heat distribution and human activity, as well as the spatial patterns of these phenomena.

For TIS-MSI collaboration, research advances have centered around environmental monitoring. Because MSI is sensitive to vegetation and land surface properties, it can be applied to study parameters correlated with LST variations derived from TIS^[30,31]. The unique spectral ranges of TIS and MSI have also facilitated the derivation of critical vegetation health indicators^[32], as well as land cover classification^[33].

For the three-sensor joint application, Dou *et al.*^[34] demonstrated the capability of this approach in monitoring ongoing disasters and conducting comprehensive post-disaster impact assessments. Following this example, SDGSAT-1's three sensors have been applied to monitor the 2025 Los Angeles wildfire^[35].

3.2 Multi-satellite Observations

With the accumulation of SDGSAT-1 data, its compatibility with other satellite data has been increasingly ex-

ploited. Taking VIIRS Day/Night Band (DNB) data as an example, although GLI has an exceptional spatial resolution, its temporal resolution is significantly outmatched by VIIRS DNB. To combine their strengths, spatio-temporal fusion between VIIRS DNB and GLI has been attempted^[36,37], yielding images applicable for global high-resolution nighttime light monitoring.

The combination of Sentinel-2 and SDGSAT-1 data has yielded results in the ecological domain. Gao *et al.*^[38] mapped soil salinity patterns using TIS and Sentinel-2 multispectral data. Jiang *et al.*^[39] showed that while multispectral data from both SDGSAT-1 and Sentinel-2 are sensitive to river features, delineation results based on SDGSAT-1 achieved better performance, likely due to its deep blue bands. For mangrove monitoring, SDGSAT-1 and Sentinel-2 data have been integrated for canopy height estimation^[40] as well as for deriving leaf nitrogen and phosphorus content^[41].

In a detailed comparison with Landsat-8/9 data, Xu *et al.*^[24] found that SDGSAT-1 data can better depict the complex urban environments due to its higher spatial resolution, while both SDGSAT-1 and Landsat-8/9 data can effectively monitor regional ecological conditions. However, because SDGSAT-1 lacks a mid-infrared band, its data are relatively ineffective for ground wetness inversion.

3.3 Global Impact

The expansion of the SDGSAT-1 Open Science Program user base has led to significant diversification of study areas using SDGSAT-1 data. For Australia^[42], Israel^[43], Switzerland^[44], the United States^[45], Italy^[46], and other European countries^[47], the research focus includes the application of GLI for studying light pollution and the development of advanced data processing techniques.

On the other hand, studies in another group of countries are more concentrated on monitoring socioeconomic status and environmental conditions. In a Colombian study, GLI data were effectively integrated into air quality modelling^[48], while the applications of GLI and TIS data of cities in Pakistan^[49–51] have yielded insights into electricity consumption and heat-related health risk mapping. Similarly, Indonesian researchers have evaluated streetlight energy efficiency using GLI data^[52]. In African countries, GLI^[53] and TIS^[54] data have been applied to study variations in nighttime light during Sahel

conflicts and to support the Great Green Wall initiative, respectively. More broadly, road network illumination levels across much of Africa have been evaluated using GLI data^[55].

4 Alliance of Sustainable Development Goals Satellites

To fully utilize existing EO platforms for the global implementation and monitoring of the SDGs, the Alliance of Sustainable Development Goals Satellites (ASSA)^{*} was established in 2022. It currently encompasses seven major Chinese EO satellite series: SDGSAT, Haiyang (HY), Fengyun (FY), Huanjing (HJ), Ziyuan (ZY), Guotuo (LT), and Gaofen (GF). Comprising over 60 satellites equipped with more than 150 sensors, ASSA delivers all-weather, 24/7 global coverage across multispectral, thermal infrared, and radar spectral domains.

As a public academic organization, ASSA focuses on defining EO service requirements for SDG applications, developing and integrating advanced EO methodologies and frameworks for SDG monitoring and implementation. It serves as an international hub for scientific collaboration and knowledge exchange, fostering dialogue among SDG stakeholders and facilitating the sharing of best practices and operational experience. Two core deliverables include a sustainable development satellite virtual constellation and dedicated SDG monitoring data products. Launched in September 2024, the first phase of the SDG satellite virtual constellation integrates SDGSAT-1, FY-3 E, HJ-2 A, HY-1 C, ZY3-03 and CBERS-04 A. ASSA is actively advancing multi-satellite data fusion and product delivery to strengthen global capacity in addressing challenges associated with SDG progress.

EO technology plays a pivotal role in advancing the 2030 Agenda, as exemplified by SDGSAT-1 and ASSA. They not only provide diverse, high-quality EO datasets for global SDG monitoring and assessment but also serve as an effective tool for investigating Earth system dynamics and human-environment interactions. In this context, during the 80th United Nations General Assembly in September 2025, Chinese Premier Li Qiang an-

nounced at the High-Level Meeting on the Global Development Initiative that China will launch an International Alliance of Sustainable Development Satellites, aiming to provide robust space-based observation data in support of global development^{**}. International partners and satellite missions are warmly invited to join ASSA, to utilize and expand its collective resources, and to share perspectives on the potential of EO across scientific research and sustainable development sectors.

5 Conclusion

As highlighted in this study, SDGSAT-1 has accomplished fruitful achievements during its operational period from 2024 to 2026 and is poised to continuously generate influential research outcomes in the future. The design and operational framework of SDGSAT-1 represent a pioneering endeavor in Earth observation dedicated to SDG implementation, laying a solid foundation for subsequent follow-up satellite programs. Spearheaded by SDGSAT-1 and CBAS, the ongoing expansion of the sustainable development satellite network and supporting infrastructure will enable Earth observation to play an increasingly pivotal role in global sustainable development initiatives. Such contributions will extend throughout the remaining implementation period of the 2030 Agenda and well into the long-term future.

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^{*} www.assa4sdg.org.cn

^{**} https://www.fmprc.gov.cn/eng/xw/zyxw/202509/t20250924_11715922.html

Conflict of Interests The authors declare that there is no conflict of interests

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