

Big Data and Remote Sensing for Monitoring Progress on SDG 13

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Abstract

Sustainable Development Goal 13 (SDG 13: Climate Action) calls for strengthening resilience and adaptive capacity to climate-related hazards and integrating climate change measures into national policies. Monitoring progress toward SDG 13 remains challenging because of limited and inconsistent data, particularly in global climate indicators. This research explores how big data and remote sensing—including satellite Earth observation (EO) data and machine learning analysis—enhance monitoring capabilities for SDG 13. The study synthesizes evidence from scientific literature and global data systems to demonstrate how big datasets from satellites (e.g., Sentinel, Landsat) and analytical tools can generate high-resolution spatiotemporal information on climate indicators, greenhouse gas emissions, disaster impacts, and ecosystem changes. Key findings show that big Earth data enables detailed tracking of variables relevant to SDG 13.1 (resilience to climate hazards) and SDG 13.2 (integration of climate measures), filling critical data gaps and supporting policy responses. However, challenges include limited remote sensing contributions to some SDG indicators, data integration issues, and unequal capacity across countries. The study concludes that integrating big data and remote sensing into SDG monitoring frameworks is vital to improving climate action accountability and decision-making.

Keywords: Big data, remote sensing, SDG 13, Earth observation, climate monitoring, satellite data.

1. Introduction

Climate change is one of the most pressing global issues of the 21st century, with impacts ranging from extreme weather events to long-term shifts in temperature and precipitation. Addressing this requires robust monitoring systems that can provide comprehensive and timely information on climate trends and their effects. Sustainable Development Goal 13 emphasizes strengthening

resilience and adaptive capacity to climate-related hazards and integrating climate change measures into national planning and policies (United Nations, 2015).

However, monitoring progress on SDG 13 is hindered by a lack of comprehensive data coverage. Many traditional data sources (e.g., national surveys, statistics) provide incomplete or irregular climate information. This limitation makes it difficult to assess progress in real time or at fine spatial resolutions, particularly in developing countries. To overcome these limitations, researchers and policymakers are turning to big data and remote sensing—advanced technologies that generate vast amounts of environmental information from satellite platforms, automated sensors, and computational models. These technologies support the detailed observation of climate-related variables such as surface temperature, greenhouse gas concentrations, disaster occurrence, vegetation cover, and ocean dynamics.

Remote sensing combined with big data analytics enables continuous, global, high-resolution monitoring essential for tracking climate change indicators and informing evidence-based policy and adaptation strategies. Through artificial intelligence, machine learning, and cloud data platforms, big Earth data has become increasingly instrumental for SDG monitoring, including SDG 13.

2. Literature Review

2.1 The Data Gap in SDG 13 Monitoring

Even though SDG 13 is critical, it suffers from significant data shortages, making assessment of targets difficult using traditional data collection methods (Guo, 2024). Remote sensing and big data analytics have expanded the capacity to generate relevant climate datasets, reducing “no data” gaps and supporting better decision-making at global scales.

2.2 Remote Sensing and Satellite Data for Climate Monitoring

Earth observation satellites like Sentinel-3, part of the European Copernicus Programme, collect data on land and ocean temperatures, sea surface height, and environmental conditions which are crucial for climate monitoring. Satellites such as Sentinel and Landsat are widely used to detect changes in temperature, ecosystems, and disaster impacts, making them fundamental for climate action and SDG monitoring. Remote sensors like CERES on NASA satellites measure Earth’s

radiation budget, offering climate-relevant insights used in global climate models and long-term trend analyses.

2.3 Big Data Analytics and Machine Learning

Big data analytics — especially machine learning models applied to remote sensing — can identify patterns in vast climate datasets and extract actionable indicators. Recent research confirms that remote sensing combined with machine learning effectively monitors environmental changes relevant to SDGs with promising accuracy. Remote sensing data has also been used to predict socio-economic variables with reasonably strong statistical associations to development indicators.

2.4 Applications for SDG 13 Monitoring

Examples of remote sensing applications include:

- Detection and analysis of flood inundation and spatial extent using multi-source imagery, supporting SDG 13.1.1 (disaster impact monitoring).
- Carbon cycle and greenhouse gas trend estimation across terrestrial and marine ecosystems using Earth observation data, supporting mitigation data streams and planning.
- Satellite measurements of sea and land surface variables that feed into climate risk models used by national policy frameworks and international assessments.

2.5 Challenges in Remote Sensing for SDG Case

Despite significant potential, remote sensing contributes to a relatively limited number of SDG indicators. Research shows that of 232 SDG indicators, only a small subset can currently use Earth observation data directly, and only one SDG 13 indicator (13.1.1) is formally recognized for EO contribution. This highlights the need for evolving methodological frameworks to incorporate remote sensing and big data more systematically.

3. Research Methodology

3.1 Research Objectives

- To evaluate the role of big data and remote sensing technologies in monitoring progress toward SDG 13.

- To identify case applications where satellite data supports climate action indicators.
- To discuss challenges and prospects for integrating remote sensing into SDG monitoring systems.

3.2 Research Design

This study uses qualitative content analysis of scientific publications, Earth observation data reports, and SDG monitoring frameworks.

3.3 Data Sources

Data and insights were gathered from:

- Big Earth Data SDG reports and thematic chapters on remote sensing applications.
- Earth observation satellite program documents such as Sentinel missions.
- Peer-reviewed analyses of EO contributions to SDGs.

3.4 Variables and Operational Definitions

Variable	Definition
Remote sensing data	Satellite or sensor data used for environmental/climate variables
Big data analytics	Computational processing of large datasets (satellite + ancillary data)
SDG 13 progress	Measurable indicators reflecting resilience and climate actions
Monitoring capacity	Ability to generate accurate, timely data for policy use

3.5 Data Analysis Techniques

Content analysis was used to synthesize literature and extract examples of how remote sensing supports SDG indicator generation and climate monitoring. Comparative evaluation of case studies was applied to illustrate real applications.

3.6 Ethical Considerations

All sources analyzed are publicly available and cited in accordance with academic standards.

4. Data Analysis / Results

4.1 Filling Data Gaps with Big Earth Data

Reports like the Big Earth Data in Support of the Sustainable Development Goals highlight that multi-source satellite and official statistics can reduce data gaps for SDG indicators, including climate-related metrics.

4.2 Sentinel and Earth Observation Contributions

EO satellites such as Sentinel-3 provide continuous measurements of sea and land surface conditions relevant to climate trends, enabling fine-scale assessments of temperature anomalies, ocean conditions, and environmental change across decades.

4.3 Remote Sensing in Disaster and Emission Monitoring

Studies using multi-source remote sensing have extracted flood extent and vulnerability data useful for assessing SDG 13.1.1 (disaster-related impacts) and correlated changes in disaster frequencies.

4.4 Machine Learning Enhancements

Machine learning applied to remote sensing data has been shown to increase the accuracy and scalability of environmental monitoring models, fostering the extraction of climate indicators relevant to SDG analyses.

5. Findings & Discussion

5.1 Enhanced Monitoring Capabilities

Big data and remote sensing significantly enhance the spatial, temporal, and thematic resolution of climate data, allowing households, communities, and policymakers to observe climate trends and episodic events, a crucial step for SDG 13 policy and action frameworks.

5.2 Limitations and Data Challenges

Even with technological advances, remote sensing data alone cannot fill all SDG data requirements; only select indicators currently rely on EO. Expanded methodologies and integration with ground data are essential for broader monitoring.

5.3 Policy and Institutional Implications

National statistical systems and international SDG monitoring frameworks must adopt big data and remote sensing products to inform decision-making, enable climate risk planning, and track mitigation progress.

6. Conclusion

6.1 Summary of Findings

Big data and remote sensing technologies are powerful tools for monitoring climate action and SDG 13 progress, offering high-resolution insights into environmental changes, disaster impacts, and mitigation pathways.

6.2 Theoretical Implications

The integration of Earth observation into SDG monitoring illustrates the evolving nature of sustainability measurement, emphasizing the need for interdisciplinary approaches combining environmental science, data analytics, and policy.

6.3 Practical/Policy Implications

Investments in satellite infrastructure, open data platforms, and analytical capacity are required to ensure that big data contributes meaningfully to climate monitoring and SDG evaluation.

6.4 Limitations

The research synthesis is contingent on currently published studies and ongoing technological developments; remote sensing contributions to SDGs are rapidly evolving.

6.5 Future Scope

Future work should explore standardized EO-based indicator methodologies and integration with national statistical systems to improve SDG data completeness.

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