International Journal of Research Studies on Environment, Earth, and Allied Sciences (IJRSEAS)
| *Volume-3 Issue-1* | *February-2026* | *ISSN: 3066-0637* | *Website:* https://eesrd.us

Manuscript ID:
IJRSEAS-2026-030115

OPEN ACCESS

Quick Response Code:

Website: https://eesrd.us

DOI: 10.5281/zenodo.21546920

DOI Link:
https://doi.org/10.5281/zenodo.21546920

Volume: 3

Issue: 1

Pp. 78-81

Month: February

Year: 2026

E-ISSN: 3066-0637

Submitted: 15 Jan. 2026

Revised: 25 Jan. 2026

Accepted: 05 Feb. 2026

Published: 28 Feb. 2026

Address for correspondence:
Anand V. Walankikikar
Department of Geography, V. D. M. D. College, Degloor, Dist. Nanded (M.H.)
Email: a.v.walakikikar@gmail.com

How to cite this article:
Walankikikar, A. V. (2026). Space-Based Technologies for Disaster Risk Reduction in India. International Journal of Research Studies on Environment, Earth, and Allied Sciences, 3(1), 78–81. *https://doi.org/10.5281/zenodo.21546920*

Space-Based Technologies for Disaster Risk Reduction in India

Anand V. Walankikikar
Department of Geography, V. D. M. D. College, Degloor, Dist. Nanded (M.H.)

Abstract

India is one of the most disaster-prone countries in the world due to its diverse physiography, monsoon-dependent climate, extensive coastline, and high population density. Floods, cyclones, earthquakes, droughts, landslides, and forest fires cause recurring loss of life and property every year. In this context, space-based technologies have emerged as powerful tools for disaster risk reduction (DRR) by enabling early warning, real-time monitoring, damage assessment, and post-disaster recovery planning. Satellite remote sensing, Global Navigation Satellite Systems (GNSS), and Geographic Information Systems (GIS) provide accurate, timely, and synoptic information that supports all phases of disaster management. This paper examines the role of space-based technologies in disaster risk reduction in India, with special reference to applications developed by the Indian Space Research Organization (ISRO). It highlights major disaster-specific applications, institutional mechanisms, challenges, and future prospects for strengthening disaster resilience through space technology.

Keywords: *Space-based technology, Disaster Risk Reduction, Remote Sensing, GIS, ISRO, India*

Introduction

Natural disasters have become increasingly frequent and intense in recent decades due to climate change, environmental degradation, rapid urbanization, and population pressure. India's geographical setting makes it highly vulnerable to multiple hazards. Nearly 60 percent of the landmass is prone to earthquakes, over 40 million hectares are flood-prone, about 8 percent of the coastline is susceptible to cyclones and storm surges, and large regions experience recurrent droughts. These disasters not only cause human suffering but also pose serious challenges to sustainable development.

Disaster risk reduction (DRR) focuses on minimizing vulnerabilities and disaster losses through preparedness, mitigation, and informed decision-making. Technological advancements, particularly in space science, have significantly transformed disaster management practices. Space-based technologies provide near-real-time data over large areas, which is not possible through conventional ground-based methods alone. In India, the integration of satellite data with disaster management systems has strengthened early warning capabilities and improved response efficiency.

This paper aims to analyze the role of space-based technologies in disaster risk reduction in India, highlighting their applications across different disaster types and management phases.

Concept of Disaster Risk Reduction:

Disaster Risk Reduction refers to systematic efforts to analyze and manage the causal factors of disasters. According to the United Nations Office for Disaster Risk Reduction (UNDRR), DRR includes measures to reduce exposure to hazards, lessen vulnerability, and improve preparedness. The Sendai Framework for Disaster Risk Reduction (2015–2030) emphasizes the use of science, technology, and innovation for understanding disaster risk and strengthening disaster governance.

In India, DRR has shifted from a relief-centric approach to a proactive, technology-driven risk reduction strategy. Space-based technologies play a central role in this transformation by supporting hazard identification, vulnerability assessment, and risk mapping.

Space-Based Technologies for Disaster Management:

1. **Satellite Remote Sensing:**

Satellite remote sensing involves acquiring information about the Earth's surface and atmosphere without direct contact. Indian satellites such as INSAT, IRS, Resourcesat, Cartosat, RISAT, and Oceansat provide multi-spectral, multi-temporal, and all-weather data for disaster monitoring. Optical satellites are useful for mapping surface features, while microwave and Synthetic Aperture Radar (SAR) satellites are effective during cloud cover and extreme weather conditions.

2. **Global Navigation Satellite Systems (GNSS):**
GNSS technology is used to monitor crustal movements, tectonic deformation, and land subsidence. In India, GNSS networks support earthquake research and tsunami early warning systems by detecting minute changes in the Earth's crust.
3. **Geographic Information Systems (GIS):**
GIS integrates satellite data with socio-economic and environmental information to create hazard zonation maps, vulnerability assessments, and risk models. GIS-based decision support systems are widely used by disaster management authorities in India for planning and emergency response.

Applications of Space-Based Technologies in Disaster Risk Reduction in India:
Table 1: Disaster Types and Satellite-Based Applications in India

Disaster Type	Satellite-Based Applications
Floods	Rainfall estimation, flood inundation mapping, river monitoring, damage assessment
Cyclones	Cyclone tracking, intensity forecasting, storm surge monitoring, early warning
Earthquakes	Seismic hazard zonation, crustal deformation monitoring, post-disaster damage mapping
Tsunamis	Sea-level monitoring, GNSS-based alerts, coastal inundation assessment
Droughts	Vegetation health assessment (NDVI), soil moisture analysis, crop stress mapping
Landslides	susceptibility mapping, slope stability analysis, terrain modeling
Forest Fires	Fire detection, hotspot monitoring, burnt area assessment

1. **Flood Management:**
Floods are among the most frequent disasters in India, particularly in the Ganga–Brahmaputra plains. Satellite imagery is used to monitor rainfall, river levels, flood inundation, and drainage congestion. ISRO's National Remote Sensing Centre (NRSC) provides near-real-time flood maps to central and state agencies. These maps help in evacuation planning, relief distribution, and damage assessment.
2. **Cyclone Monitoring and Early Warning:**
India's eastern and western coasts are vulnerable to tropical cyclones. Geostationary satellites such as INSAT-3D and INSAT-3DR continuously monitor cyclone formation, movement, and intensity. Satellite-derived data on sea surface temperature, cloud patterns, and wind speed have significantly improved cyclone forecasting accuracy, reducing loss of life through timely warnings.
3. **Earthquakes and Tsunami Warning:**
Although earthquakes cannot be predicted precisely, space-based technologies help in identifying seismic hazard zones and monitoring crustal deformation. India's Tsunami Early Warning Centre (ITEWC) integrates satellite communication and GNSS data to provide timely tsunami alerts for coastal regions.
4. **Drought Assessment:**
Droughts affect large parts of India, especially arid and semi-arid regions. Satellite-based vegetation indices such as the Normalized Difference Vegetation Index (NDVI) and soil moisture data are used to assess drought severity and agricultural stress. These assessments support crop insurance schemes and drought mitigation planning.
5. **Landslides and Forest Fires:**
High-resolution satellite data and digital elevation models are used to identify landslide-prone zones in the Himalayan and Western Ghats regions. Similarly, satellite-based thermal sensors help in early detection and monitoring of forest fires, enabling rapid response by authorities.

Institutional Framework in India:
Table 2
Major ISRO Satellites and Their Applications in Disaster Management

ISRO Satellite	Sensor Type	Major Disaster Management Applications
INSAT-3D / 3DR	Meteorological	Cyclone tracking, weather forecasting, early warning
Resourcesat	Optical	Flood mapping, drought assessment, land-use analysis
Cartosat Series	High-resolution optical	Damage assessment, urban disaster mapping
RISAT Series	Microwave / SAR	All-weather flood monitoring, landslide detection
Oceansat	Ocean colour & wind	Cyclone intensity analysis, fisheries and coastal studies

The Indian Space Research Organisation (ISRO) plays a central role in disaster management through its Disaster Management Support (DMS) Programme. ISRO collaborates with the National Disaster Management Authority (NDMA), state governments, and international agencies to provide satellite data and technical support. India is also a signatory to the International Charter on Space and Major Disasters, which facilitates global data sharing during major disaster events.

The Indian Space Research Organisation (ISRO) plays a central role in disaster management through its Disaster Management Support (DMS) Programme. ISRO collaborates with the National Disaster Management Authority (NDMA), state governments, and international agencies to provide satellite data and technical support. India is also a signatory to the International Charter on Space and Major Disasters, which facilitates global data sharing during major disaster events.

Challenges and Limitations:

Despite significant progress, several challenges limit the full utilization of space-based technologies in disaster risk reduction. These include limited technical capacity at local levels, delays in data dissemination, lack of trained manpower, and difficulties in integrating satellite data with ground-based information. Data accessibility and interpretation remain critical issues, particularly for rapid decision-making during emergencies.

Future Prospects:

The future of space-based disaster management in India lies in the integration of artificial intelligence, machine learning, and big data analytics with satellite observations. The growing use of small satellites and CubeSats promises higher temporal resolution and cost-effective monitoring. Strengthening institutional coordination, capacity building, and public awareness will further enhance the effectiveness of space-based technologies in disaster risk reduction.

Conclusion:

Space-based technologies have become indispensable tools for disaster risk reduction in India. From early warning and preparedness to response and recovery, satellite data and geospatial technologies support informed decision-making and significantly reduce loss of life and property. Indian experiences clearly demonstrate that timely satellite-based cyclone warnings, flood inundation maps, drought assessments, and forest fire alerts have improved disaster response efficiency and resilience.

As disaster risks continue to intensify due to climate change, urban expansion, and environmental stress, reliance on space-based observations will further increase. Strengthening institutional coordination between ISRO, NDMA, state disaster management authorities, and local administrations is essential. Capacity building, improved data dissemination, and integration of emerging technologies such as artificial intelligence and real-time analytics will enhance the effectiveness of disaster risk reduction strategies. Overall, space-based technologies will remain central to building a disaster-resilient and sustainable India.

Policy Implications and Recommendations:

The effective use of space-based technologies for disaster risk reduction requires supportive policy frameworks and long-term planning. Policymakers must prioritize investment in satellite infrastructure, data-sharing mechanisms, and capacity building at national, state, and local levels. Disaster management plans should mandate the integration of satellite-based information into early warning systems and emergency response protocols.

There is a need to strengthen collaboration between scientific institutions, government agencies, and local communities to ensure that satellite-derived information reaches end users in a timely and understandable form. Encouraging open-access satellite data policies and promoting public–private partnerships can further enhance innovation in disaster management applications.

Acknowledgment

I express my sincere gratitude to all those who have supported and guided me in the completion of this research paper titled *"Space-Based Technologies for Disaster Risk Reduction in India."*

I am deeply thankful to the Principal and the Department of Geography, V.D.M.D. College, Degloor, for providing the necessary academic environment, facilities, and encouragement required for this study.

Financial support and sponsorship

Nil.

Conflicts of interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

References:

1. Indian Space Research Organisation (ISRO). (2023). *Satellite Applications for Disaster Management*. ISRO, Department of Space, Government of India.
2. National Disaster Management Authority (NDMA). (2020). *National Disaster Management Plan*. Government of India.
3. United Nations Office for Disaster Risk Reduction (UNDRR). (2015). *Sendai Framework for Disaster Risk Reduction 2015–2030*. United Nations.

4. National Remote Sensing Centre (NRSC). (2022). *Remote Sensing Applications in Disaster Management*. ISRO.
5. Gupta, A., & Nair, S. (2019). Application of geospatial technologies in disaster management in India. *Journal of the Indian Society of Remote Sensing*, 47(5), 789–803.
6. Roy, P. S., Diwakar, P. G., & Dwivedi, R. S. (2018). Satellite remote sensing applications for natural resource management in India. *Current Science*, 114(7), 1351–1362.
7. Mishra, A., & Singh, V. P. (2010). A review of drought concepts. *Journal of Hydrology*, 391(1–2), 202–216.
8. Dash, J., & Jeganathan, C. (2016). Drought monitoring using remote sensing in India. *International Journal of Applied Earth Observation and Geoinformation*, 43, 1–10.
9. Ramesh, D. S., & Satheesh, S. K. (2017). Space-based observations for cyclone monitoring over the Indian Ocean. *Meteorological Applications*, 24(4), 564–576.
10. Srivastava, P. K., Han, D., Rico-Ramirez, M. A., & Islam, T. (2014). Data fusion techniques for improving flood forecasting. *Advances in Water Resources*, 71, 123–135.
11. Jain, S. K., Agarwal, P. K., & Singh, V. P. (2007). *Hydrology and Water Resources of India*. Springer.
12. ESA. (2021). *Earth Observation for Disaster Risk Reduction*. European Space Agency.
13. NASA Earth Observatory. (2020). *Satellite Observations and Natural Hazards*. NASA.
14. International Charter on Space and Major Disasters. (2022). *Annual Report*.
15. Cutter, S. L., Burton, C. G., & Emrich, C. T. (2010). Disaster resilience indicators for benchmarking baseline conditions. *Journal of Homeland Security and Emergency Management*, 7(1), 1–22.
16. Zhang, Y., Li, Z., & Chen, F. (2019). Satellite monitoring of landslides and geological hazards. *Remote Sensing*, 11(3), 1–18.
17. Choudhury, S., & Das, A. (2021). Forest fire detection and monitoring using satellite data in India. *Environmental Monitoring and Assessment*, 193(4), 1–15.
18. World Meteorological Organization (WMO). (2018). *Multi-hazard Early Warning Systems*. WMO.
19. Government of India. (2021). *India Disaster Resource Network*. Ministry of Home Affairs.
20. Campbell, J. B., & Wynne, R. H. (2011). *Introduction to Remote Sensing* (5th ed.). Guilford Press.