

**SATSURE**



# **Geospatial Foundation Models as an Enabler of Earth Observation Impact at Scale**

# Understanding Foundational Models

The world has moved from narrow, task-based machine learning (ML) models to **foundational models**, general-purpose intelligence systems trained on large, heterogeneous datasets and capable of solving multiple types of problems.

A good example is the rise of **Large Language Models (LLMs)**, such as GPTs, which can answer questions, summarize content, and power multiple applications using the same core intelligence. These models are trained and continuously improved using prompts across diverse inputs and tasks.



## Geospatial Foundation Models: The Next Frontier of AI in Earth Observation

**Geospatial Foundation Models (GFMs)** bring this shift to satellite imagery and Earth Observation (EO). A GFM is trained on vast and diverse EO datasets, and can support a wide range of applications, from crop monitoring to flood assessment, without rebuilding task-specific models each time.

The last two decades have seen a surge in satellite imaging capacity. Programs like **Sentinel**, **Landsat**, and **Planet** now generate petabytes of data. **Copernicus** alone collects over **234 TB of EO data daily**. However, this abundance introduces a new bottleneck: converting data into actionable intelligence, consistently and at scale.

Public-sector institutions face fragmented workflows, data from multiple vendors, differing formats, and bespoke models with limited reusability. Scaling insights across states or schemes often means reinventing the wheel.

GFMs solve this by offering a **common, reusable intelligence layer**. Like LLMs for text, they understand patterns across geography, time, and sensors, enabling faster, cheaper, and more consistent outputs for diverse tasks<sup>2,3</sup>.

Unlike traditional EO models, narrow in scope and trained on local datasets, GFMs are built on multi-modal, multi-sensor, and multi-temporal Earth imagery. They learn **spatiotemporal representations** that can be fine-tuned for specific downstream tasks. This leads to major efficiency gains.

# Understanding Foundational Models

## Prominent examples include:

- **SatMAE** by ESA Φ-lab and ETH Zurich, which uses masked autoencoding on Sentinel-2 data, outperforming supervised baselines for land cover and phenology <sup>4</sup>.
- **Prithvi** by IBM and NASA Harvest, trained on 524 TB of HLS data and deployed for flood detection, crop segmentation, and more, without retraining <sup>5</sup>.
- **CrossEarth** from Tsinghua and MIT, trained on 13 satellite datasets, which outperforms conventional models by up to 4× across geographies <sup>6</sup>.

These models are now integrated into platforms like **Google Earth Engine's Earth-2 ML**, **Radiant Earth**, and **NASA Harvest** workflows.



In India, this momentum is being led by **SatSure and KaleidEO**. KaleidEO is building upstream capacity through a constellation of **AI-enabled satellites** with high-resolution multispectral sensors. SatSure, in parallel, is building a sensor-agnostic, foundation-model-enabled downstream layer that supports national-scale applications in agriculture, infrastructure, forestry, aviation, and disaster response.

GFMs' core strength is **modularity and reuse**: a crop model trained in Punjab can work in Odisha; a land cover model built for encroachment detection can be adapted for disaster relief.

However, deployment at scale requires strong upstream data pipelines, domain-level fine-tuning, and governance-ready integration. GFMs must also be explainable and auditable, especially in critical public workflows.

Still, their arrival marks a new chapter: a shift from handcrafted, project-specific analytics to **shared, scalable, and interoperable EO infrastructure** that is ready for public sector adoption.

# From Model to Mission: Foundation Models as Scalable Infrastructure

Training a geospatial foundation model is just the starting point. The real value emerges when these models are embedded into day-to-day governance, **supporting decisions that shape infrastructure, insurance, or environmental response**. A model that can flag flood risks in Assam and map crops in Maharashtra, without needing to be rebuilt for each task, isn't just more efficient, it's transformational.

GFM's excel because they generalize well. With **few-shot learning**, one trained model can adapt to new regions or programs with minimal effort. This eliminates the constant cycle of retraining and customization that has historically slowed Earth Observation deployments.

Crucially, they bring efficiency to every stage of the EO pipeline:



**Ingestion:** They can fuse and interpret data from multiple sensors, regardless of format.



**Processing:** They reduce the need for large labeled datasets, speeding up model tuning.



**Application:** Their outputs integrate smoothly into dashboards, APIs, and existing public-sector tools.

As one recent survey of remote sensing architectures noted, foundation models "act as a geometric prior," helping accelerate deployment, especially in low-resource environments where fast turnaround is essential for government-linked applications <sup>7</sup>.

# Why India Is Ready for This

India stands at a unique inflection point. The building blocks for national-scale GeoAI infrastructure are already being assembled:

- The **National Geospatial Policy 2022** lays the foundation for real-time, interoperable intelligence across ministries <sup>12</sup>.
- Programs like **EO-PPP** are constructing sovereign, multi-sensor satellite infrastructure, improving data availability and control <sup>8</sup>.
- DPI platforms, **Bhuvan**, **GatiShakti**, **AMRUT**, are digitizing program delivery at scale, creating fertile ground for plug-and-play intelligence.

To truly unlock these capabilities, India must adopt a **full-stack approach** to GeoAI:

- **Upstream:** Sovereign sensing through high-resolution, edge-enabled satellites like KaleidEO's.
- **Midstream:** Shared foundation models trained on India-specific geographies and temporal patterns.
- **Downstream:** Real-time delivery into tools aligned with how ministries monitor, report, and act.



This isn't theoretical. SatSure and KaleidEO are already delivering this blueprint in practice. Their combined architecture allows ministries to **query live geospatial intelligence**, a system that learns continuously, scales rapidly, and integrates seamlessly into governance workflows.

If India treats **GeoAI infrastructure** as a core public good, on par with roads, power, or digital identity, it will not only leapfrog legacy bottlenecks but also **define the global playbook** for spatial intelligence in public systems.

# Traditional EO Models vs. Geospatial Foundation Models

Feature / Capability	Traditional EO Models	Geospatial Foundation Models (GFM)
<b>Training Scope</b>	Task-specific, narrow geography	Multi-task, multi-geography, multi-sensor
<b>Data Requirement</b>	High-quality labeled datasets	Can train with limited or unlabeled data
<b>Sensor Adaptability</b>	One model per modality	Learns across optical, radar, hyperspectral
<b>Reuse Across Programs</b>	Low	High (zero-/few-shot generalization)
<b>Operational Scalability</b>	Manual customization required	Plug-and-play deployment
<b>Cost per Deployment</b>	High (per project)	Declining marginal cost
<b>Update Cycle</b>	Re-train per use case	Fine-tuning or prompting only

India’s Earth Observation Public-Private Partnership (EO-PPP) is building a modern, multi-sensor satellite infrastructure. While its primary focus is upstream data generation, such initiatives lay the groundwork for advanced analytics, including foundation-model-enabled systems, by improving data availability, continuity, and national ownership <sup>8</sup>.

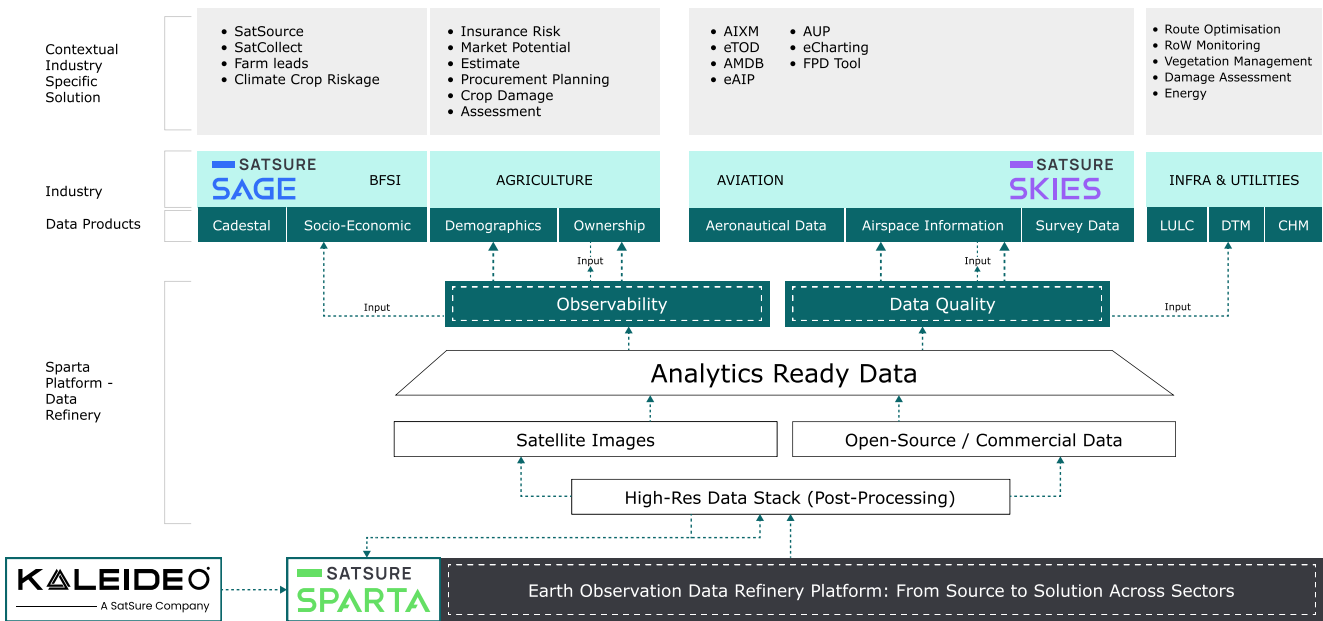
Ultimately, the impact of GFMs is not about technical elegance. It’s about enabling **resilient, repeatable, and trusted intelligence**, across rural finance, disaster relief, agriculture, and environmental planning. That’s when a model becomes more than code, it becomes public infrastructure.







# The SatSure-KaleidEO Full-Stack Play

For geospatial foundation models (GFM) to drive real-world change, they must operate within a system built for scale, **from satellite capture to ministerial action**. This is the logic behind the SatSure-KaleidEO full-stack approach.

**Upstream**, KaleidEO is deploying a constellation of 1m resolution satellites, designed not only for imaging but also for **onboard AI processing**, filtering clouds and flagging objects directly in orbit. This reduces latency and streamlines the data pipeline.



**Downstream**, SatSure pulls this feed into its analytics platform, powered by domain-specific GFM. These models are trained on multi-year, multi-sensor data from diverse Indian geographies and support a wide spectrum of use cases:

 <p><b>Agriculture:</b> Crop type mapping, yield estimation, credit risk scoring</p>	 <p><b>Utilities:</b> Transmission route planning, vegetation encroachment monitoring</p>
 <p><b>Forestry and Carbon:</b> Canopy degradation, MRV (Measurement, Reporting, Verification)</p>	 <p><b>Disaster Response:</b> Flood extent and severity mapping</p>

# The SatSure-KaleidEO Full-Stack Play

What sets this system apart is the **tight coupling of sovereign sensing with scalable intelligence**. GFMs enable rapid adaptation across tasks, while **Agentic AI** elements, now being prototyped, add the ability to autonomously monitor, escalate, or simulate decisions. These aren't just dashboards, they are evolving agents aligned with institutional goals.

## The result:

- Faster turnaround from image to insight
- Reduced need for manual calibration or external tooling
- Deep integration with national digital infrastructure and governance workflows

As EO-PPP and other mission-mode programs scale, the SatSure-KaleidEO stack offers a replicable template, **not just for technology deployment, but for systemic integration**.



# From Platform to Impact: A Full-Stack, Multi-Sector Model

It's one thing to build a powerful model. It's another to see it shape real decisions on the ground. That's where SatSure and KaleidEO's full-stack approach comes into its own. The real measure of a GFM isn't how well it performs on a benchmark, it's whether it can help a policymaker act faster, more accurately, and with more confidence.

Together, the two entities form a unified system: upstream satellites collecting high-resolution imagery, and downstream models delivering **decision-grade outputs** to institutions across sectors.

## Agriculture and Agri-Finance

In farming, where decisions are time-sensitive and hyper-local, SatSure's GFM-backed Sage platform has already made a difference. It supports decision-making for over **2.1 million farms across 195,000 villages**, working with leading banks and NBFCs. The platform enables:



**2.1 million farms**  
across 195,000 villages



Yield risk estimation



Accurate crop type detection



Geotagged field boundaries compliant with PMFBY and KCC



# From Platform to Impact: A Full-Stack, Multi-Sector Model

## Power and Transmission Infrastructure

For India's expanding green energy grid, precision matters. Thousands of kilometers of new power lines are being planned. SatSure's **Route Optimization engine**, powered by EO and machine learning, helped a major power firm align **90% of its final transmission route** with the AI-recommended path. The result?



**3× faster planning**, completed in hours instead of weeks



Improved BoQ accuracy, leading to better bids and smoother regulatory approval



Reduced land acquisition friction and implementation delays

That system is now being integrated into the company's pan-India rollout pipeline.

## Forestry and Carbon Monitoring

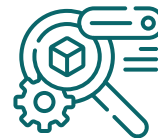
Forests are hard to monitor: seasonal shifts, inaccessible terrain, and overlapping threats. SatSure Forest was developed to bridge that gap using **foundation models trained on multi-sensor, multi-year imagery**. In partnership with a state forest department and a UN-backed climate group, it now monitors **over 667,000 hectares** in eastern and central India. It delivers:



Monthly canopy change alerts



NDVI anomaly detection



Heat stress tracking

These insights support REDD+ targets, carbon credit MRV, and patrol planning, bringing long-term visibility to a sector where it's often missing. Across all these cases, one thread connects them: impact comes not from the model alone, but from how it's delivered, as a system, not a service.

# Aligning GFMs with Policy and Public Sector Intelligence

For GFMs to create lasting value in India, they need to do more than just perform technically. They must be **institutionally aligned**, built to serve the actual way governance happens.

The most effective models are those that mirror how ministries think: they align with **Key performance indicators (KPIs)**, match operational timelines, and fit into reporting and decision cycles.

Many critical national programs already use EO, but often in fragmented or pilot-based ways. GFMs offer a way to streamline and scale these efforts by becoming the common analytical engine that serves multiple ministries at once.

Consider the following national programs:

- **Pradhan Mantri Fasal Bima Yojana (PMFBY):** India's flagship crop insurance scheme integrates remote sensing for yield estimation and claim settlement. GFMs can generalize across crop types and agro-climatic zones, reducing dependence on manual crop-cutting experiments.
- **National Mission for Clean Ganga (NMCG) and AMRUT:** Urban and water missions rely on EO-based monitoring of encroachment, drainage, and land use. GFMs enable rapid segmentation and change detection across seasons and urban typologies.
- **State Forest Departments: Agencies tracking forest health or carbon sequestration face a shortage of skilled GIS teams.** Foundation models trained on dense canopy regions can generalize to new terrains with minimal retraining, aligning with India's REDD+ MRV goals.

Policy is already moving in this direction. **The National Geospatial Policy (NGP) 2022** calls for open APIs and decision-ready dashboards across government. GFMs make that vision real by connecting satellite data, machine learning, and governance platforms into a single layer of shared intelligence.

# Aligning GFM's with Policy and Public Sector Intelligence

Equally important, these models improve **auditability and feedback loops**. For instance, if a crop failure is flagged by a foundation model under PMFBY, that signal can trigger targeted field inspections, helping administrators respond faster and with more confidence.

As India builds out its **digital public infrastructure**, from Bhuvan and GatiShakti to EO-PPP constellations, GFM's will be the glue that holds it all together. They won't replace decision-makers, they'll empower them to make better, faster, and fairer calls.



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# About SatSure

We harness the power of cutting-edge technologies in satellite remote sensing, artificial intelligence, machine learning, and cloud computing to build innovative products and solutions.

Our innovative solutions facilitate seamless digital transformation, enabling stakeholders to optimize processes and significantly reduce capital and operational expenses. By leveraging near real-time analytics from high-resolution earth observation data, we empower organizations with actionable insights for precise planning and efficient decision-making.

SatSure is dedicated to revolutionizing industries with decision intelligence from space across such as aviation, infrastructure, energy, and utilities through advanced technologies, enhancing operational efficiency, and driving sustainable growth for our valued clients.



## Have questions?

To know more about our work at SatSure, reach out to us at [info@satsure.co](mailto:info@satsure.co)

