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Opinion Piece

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Harnessing LEO Satellites for Climate-Smart Agriculture and Biodiversity Conservation

BIODIVERSITY | SUSTAINABILITY | CLIMATE SMART AGRICULTURE

1. Introduction: Can Space Technology Solve Our Food and Climate Crisis?

We are living at a critical point in time, where the issues of climate change, food security, and biodiversity should no longer be treated as separate concerns but rather on a scale where they have a huge ripple effect on one another, requiring non-traditional solutions to address them. While agriculture is vital for human survival, unfortunately, it has become one of the leading causes of deforestation, soil degradation, and excessive freshwater consumption. On the flip side, climate change has made farming more volatile, leading to the whole concept of food production being affected by extreme weather conditions, which creates unwarranted issues in supply, thereby raising food prices and severely affecting marginalized communities.

Beyond the environmental perspective, we must also examine the economic issues associated with disruptions in agriculture due to climate change. Insurance costs alone have risen significantly over the years, making farming an increasingly difficult industry to sustain. The Financial Times (2023) indicated that the cost of insuring any assets within agriculture against climate change effects has gone up by 40 percent in the last decade alone—which begs the question of the need for better and more accurate risk assessment models that rely on real-time environmental data. All this is to say that there is a greater need for cutting-edge, predictive technologies to monitor, manage, and mitigate climate risks in the field of agriculture.

But there is hope—solutions are emerging through the use of Low Earth Orbit (LEO) satellites, which create super high-resolution images and capture far more accurate environmental data. For the first time, we have real-time insights on all aspects of agriculture, including land usage, soil moisture, and even climate volatility. The key difference between LEO satellites and GEO satellites (which is what we typically think of when we imagine satellites) is that while GEO satellites can cover larger areas, LEO satellites orbit Earth at a much lower altitude of only five hundred to two thousand kilometers. This significantly reduces latency in data transfer, enabling precision tracking capabilities.

Now the question lies in creating the optimum solution. By integrating AI–powered analytics, blockchain measures for transparency, and even quantum sensing for ultra-precise measurements, LEO satellites can become the ultimate tool for building a smart agriculture ecosystem.

This article explores how LEO satellites, combined with emerging technologies, can help safeguard global food systems and, more importantly, support biodiversity conservation, pushing the boundaries of how space tech is advancing humanity with an ecological lens.

2. How Are Satellites Making Farming Smarter and More Sustainable?

2.1 Can We Use Space Data to Grow More Food with Fewer Resources?

If we look at history, traditional farming has relied heavily on local observation and a reactive way of operating when it comes to action, making it far more susceptible to climate change issues. However, providing farmers access to LEO satellites could significantly enhance their ability to monitor and detect crop stress, soil degradation, and even water resource issues in a much more accurate, real-time manner.

The way it works is by combining different types of sensors in LEO satellites, some of them being hyperspectral and multispectral types, which provide the benefit of early detection when it comes to plant nutrient deficiencies, pest outbreaks, and even drought stress—much earlier than the time frame we currently have, in some cases even before the first symptoms appear to the naked eye. This type of insight allows farms to be far more proactive in managing irrigation, fertilization, and pest control systematically.

A strong example of this would be NASA's ECOSTRESS mission, which uses thermal imaging to monitor plant water stress (NASA ECOSTRESS Mission 2023). We found that if farmers were to monitor this, they could reduce water consumption by up to 30 percent while simultaneously increasing yield. We also learned that the European Space Agency's Sentinel satellites have and will continue to play a bigger role in crop health assessment, which, in fact, helps agribusinesses implement forecasting measures on production fluctuations and adjust supply chain mechanisms as needed (Sentinel-2 Satellite Mission 2024).

2.2 How Are Satellites Solving the Water Crisis in Agriculture?

Now if we realize how much water is being used for agriculture, then our entire perspective on this issue and why we need a better way to monitor it would change. On average, 70 percent of the world's fresh water is being used. This is where LEO satellites become crucial—they provide real-time monitoring of groundwater levels, understanding precipitation levels, and even assessing soil moisture conditions, all of which are equally important for creating smart-based water irrigation systems that will eventually aid in drought preparedness.

We already have a working version of this, called the GRACE (Gravity Recovery and Climate Experiment) satellite mission. This has changed the concept of groundwater monitoring, allowing policymakers to implement better regulations on water extraction policies and prevent aquifer depletion. Compared to their GEO or MEO counterparts, LEO satellites offer superior Earth Observation (EO) capabilities. When paired with Synthetic Aperture Radar (SAR)—which can penetrate darkness and adverse weather conditions—we are ultimately creating a 24-7 monitoring mechanism for farmers to understand flood patterns and water reserves, thereby enabling them to plan their farming cycles far more effectively (Gravity Recovery and Climate Experiment 2023).

And it's working as intended. We recently saw in The World Economic Forum's Playbook on Earth Observation (2025) report that combining satellite data with AI capabilities is allowing for enhanced predictive modeling, leading to an average reduction of 15 to 30 percent in agricultural water waste at test locations (World Economic Forum 2025). These forms of data-driven mechanisms are revolutionizing water conservation as we know it in a far more sustainable and actionable manner.

3. Can Satellites Help Reverse Biodiversity Loss?

3.1 Tracking Deforestation and Protecting Critical Ecosystems

One of the shocking revelations is that since the 1970s, global biodiversity, as we know it, has declined by 50 percent. A big culprit here would be deforestation, habitat destruction, and, of course, climate change. That's where LEO satellites come in—with their unprecedented ability to monitor changes in the landscape at various intervals, allowing us to preserve and, if anything, regain what we have lost in the past (European Space Agency 2023).

A good use case in this field is the Amazon rainforest protection project led by NASA's Terra and Aqua satellites, which significantly reduced deforestation by as much as 80 percent (from twenty-five thousand square kilometers per year in 2004 to five thousand square kilometers by 2012) (NASA Earth Observatory 2012). If anything, this success underscores the importance of real-time data for biodiversity conservation.

3.2 What Is Regenerative Agriculture, and How Does It Differ from Conservation?

There is no one-method-fits-all approach to farming—this is where regenerative agriculture comes into play. It's a type of farming that includes a 360-degree view of rebuilding soil health, increasing biodiversity, and enhancing ecosystem resilience while we are at it. This is vastly different from the traditional type of conservation, which only focuses on preservation. Instead, regenerative agriculture actively restores degraded lands and enhances soil carbon sequestration.

A good example of this is the ICESat-2 satellite mission, which monitors tree canopy growth within agroforestry systems, granting farmers insights into sustainable land-use methods. If we were to combine regenerative agriculture with LEO satellite data, then we would be putting ourselves in a great spot to transform agriculture from being a cost to an enabler of ecosystem restoration.

4. Can Emerging Technologies Supercharge Satellite Data?

4.1 Quantum Sensing: The Future of Environmental Monitoring?

Quantum sensing also adds another layer of capability to existing EO satellites. The 2024 McKinsey Quantum Technology Monitor report articulated that quantum sensing will further revolutionize EO by enabling the detection of gravitational changes, atmospheric pressures, and even underground water movements with extreme accuracy (McKinsey & Company 2024).

Progress is already underway on this. The ESA's Quantum Metrology Initiative is currently making strides in developing the next phase of EO satellites equipped with quantum sensors. These sensors provide submillimeter accuracy in measuring land deformation, ocean current levels, and climate patterns. Such advancements are further scaling the role of LEO satellites in accelerating biodiversity sustainability measures—an urgent necessity in today's environmental landscape (European Space Agency 2024).

5. Conclusion: Will We Use Space to Protect Our Planet?

Agriculture is undeniably essential, yet it faces severe adverse challenges due to climate change—challenges that demand urgent solutions. The concept of digital transformation is not a nice-to-have but a means for sustainability. LEO satellites, when layered with AI, blockchain, and quantum sensing, are the next-level monitoring tool that is ever more important to save biodiversity and create a future of climate resilience. Combining all these efforts, we see a path where smarter and more sustainable agriculture systems will not only feed humanity but also help save our planet.

The question of what we must do moving forward is clear: We must enhance governmental efforts to expand satellite-based environmental capabilities while fostering collaboration with the private sector—ensuring that such data is accessible to farmers, researchers, and anyone in this ecosystem to improve biodiversity. Additionally, businesses must recognize satellite analytics in sustainable strategies and integrate emerging financial innovations such as regenerative finance (ReFi), which can further add capital to biodiversity protection through blockchain-based funding models (IIED 2023).

The new space economy is not just about exploring the cosmos; it’s about safeguarding Earth. By leveraging LEO satellites alongside digital finance and advanced sensors, we can reshape what has been lost and create more for the future, ensuring a food-secure and biodiversity-rich world for generations to come.

Author

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Rajeeshwaran Moorthy is a strategy and space economy leader, specializing in investment foresight, commercialization, and policy development for space-based industries. As managing director and chair of Space Sector at The Chart Think Tank, he advises governments, private sector stakeholders, and startups on space commercialization, satellite data monetization, and strategic foresight. He is also a research fellow at École des Ponts (CPC Paris), an executive fellow at the Digital Economist, and visiting faculty at a few business schools where he leads space economy courses for executives and postgraduates. A two-time TEDx speaker, Rajeeshwaran is the author of Space Economy: A Beginner's Guide (Routledge, Taylor, and Francis 2026), offering insights into how space commercialization is shaping global industries. His expertise bridges business strategy, policy engagement, and the future of space-driven economies. He also serves as the strategic adviser for Space Marketplace, an all-in-one platform that simplifies access to downstream space services.

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