# From Space to Soil: The Potential of Space-based Technologies for African Agricultural Transformation

Ola Mirzoeva

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# Contents

## Author

**Ola Mirzoeva**
**ola.mirzoeva@gmail.com**
Mirzoeva is a student in the combined JD (Common Law) and MA (International Affairs) programme offered by the University of Ottawa's Faculty of Law and Carleton University's Norman Paterson School of International Affairs. Mirzoeva's work is also informed by her interdisciplinary studies with the International Space University in Houston in partnership with the NASA Johnson Space Centre, and with Canada's Centre for International Governance Innovation (CIGI) as Digital Policy Hub Fellow, where her research focused on outer space governance. In this Working Paper, Mirzoeva draws on, inter alia, 2024 field work, supported by Open AIR, that was conducted in Nairobi, where she interviewed space-sector stakeholders on the potential barriers to, and prospects for: international cooperation in space; and more deeply embedding space technologies in the Kenyan economy.

The author will be grateful for inputs and feedback on the contents of this Working Paper. Please use the author's email address provided above.

## Methodology

For the purpose of analysing and disseminating findings in the literature that could inform high-impact international development partnerships involving space-based technologies (with a focus on Canada as a partner), this paper's approach was informed by the scoping-study methodology set out by Arksey and O'Malley (2005).

## Abstract

This Open AIR Working Paper 33 explores the potential for space-based technologies to support African agricultural productivity and to address economic transformation hindered by agricultural heterogeneity. Earth observation (EO) satellite applications for precision agriculture can offer targeted solutions, with early evidence across the continent showing improved yield forecasting, reduced food waste, and higher household incomes. The paper also examines the reality that, as traditional overseas development assistance (ODA) declines in Africa, space cooperation may present a viable "post-aid" development pathway, through which countries such as Canada can forge valuable partnerships with African nations. Such partnerships with African countries would align with: Canada's recently published Africa Strategy (2025); Canada's rich experience in the space sector, including the RADARSAT programme and cooperation with the European Space Agency (ESA) and other partners; and the need for Canada and its African partners to advance technically grounded and commercially scalable cooperation initiatives.

## Key Takeaways

Key takeaways that emerge from this paper include:

- Agriculture remains the launchpad of livelihoods for most households in Sub-Saharan Africa (SSA), where approximately 80% of farmers are smallholders and agriculture accounts for up to two thirds of GDP.

- Space-based technologies can help address core agricultural constraints—especially environmental heterogeneity—that have stifled agricultural-sector growth in SSA, by enabling precision farming, real-time crop and livestock monitoring, and risk-informed access to credit and insurance.
- Early evidence shows material impacts from satellite-enabled insurance and early warning systems, including improved yield forecasting, up to 20% reduction in food waste, and higher household incomes.
- Space cooperation offers a viable "post-aid" development pathway for donors in alignment with African priorities (the AU's Agenda 2063, the African Space Policy and Strategy), the Space2030 Agenda, international obligations in the Outer Space Treaty, and Canada's Africa Strategy.
- Spacefaring countries such as Canada can support development outcomes (in agriculture and beyond) through space cooperation with African governments, institutions and companies.

## Keywords
outer space, Earth observation (EO), precision agriculture, smallholder agriculture, Sub-Saharan Africa (SSA), development, aid, official development assistance (ODA), cooperation, Canada

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# I. Context: Agriculture's Enduring Role in Development and a Changing Aid Landscape

### A. The Role of Agriculture in Economic Growth

Despite the potential promise and perils of disruptive technologies such as artificial intelligence (AI) and quantum computing, conventional wisdom (supported by recent studies) holds that the key to transforming Sub-Saharan Africa's (SSA's) economies is firmly rooted in agricultural development (Diao et al., 2010). Agriculture is especially important for addressing rural poverty, given how many livelihoods it touches, as well as its large share of GDP in SSA (between one third and two thirds of GDP, depending on the country) (Diao et al., 2010, p. 1376). Roughly 80% of SSA's farmers are smallholders, and agriculture's shares of GDP and employment in SSA are the largest of any region in the world (Suri & Udry, 2022). Efforts to improve agricultural productivity in SSA have historically yielded little growth, and agricultural productivity in the region lags behind that of the rest of the world (Suri & Udry, 2022). SSA's historically low growth in agricultural productivity has been connected to factors such as low levels of research and development (R&D) investment, institutional shortcomings, and the geography of the continent itself—specifically the heterogeneity of soil and climate (Sury & Udry, 2022).

### B. New Models of Development Cooperation Amidst Shrinking Global Aid

With foreign aid declining globally following the dismantling of the US Agency for International Development (USAID) and cuts by Germany, France, and the UK (OECD, 2025), a new "post-aid" world is being conceived of by the historically large donors, in anticipation of new pathways for achieving development outcomes (ODI, n.d.). Similarly, Canada's 2025 federal budget saw a CAD2.7 billion decrease in official development assistance (ODA) over four years (Government of Canada, 2025a, p. 209). At the same time, Canada's Africa Strategy—the first such strategy for the country, released in 2025—gives focus to areas beyond traditional donor-recipient programmes, prioritising partnerships that enhance security and mutual economic prosperity (Global Affairs Canada, 2025). With ODA decreasing globally, partnerships and joint investments that leverage technology for mutual benefit can offer ways to advance development goals that were traditionally pursued through aid funding.

### C. The Promise of Outer Space Applications for Development

The 1967 Outer Space Treaty sets the legal foundation for space activity, guaranteeing "free access to the exploration and use of space by all States", and "benefits for all countries irrespective of the degree of economic or scientific development" (Outer Space Treaty, 1967, art. 1). Historically, space-faring states reaping such benefits tended to be in the Global North, but in recent decades, participation by other nations, particularly, China and India, has grown rapidly.

African countries have historically questioned whether the benefits of space are being shared as widely as the Outer Space Treaty guarantees. This concern and the response of the international community were captured by a 1996 UN General Assembly (UNGA) Declaration that specifically called for "the needs of developing countries" to be served.[1] Notwithstanding African nations' critiques of the implementation of the Outer Space Treaty, a growing cohort of African nations—21 countries, as of early 2026—have formalised their engagement in the space sector through establishing space agencies, reflecting a strategic shift towards integrating space capabilities into national development planning (Africa Center for Strategic Studies, n.d.).

The 1996 UNGA Declaration was followed by a practical mapping of how space applications can advance development outcomes, yielding the UN's Space2030 Agenda (UNOOSA, 2023, 2024). The Agenda, which aligns with the UN's Sustainable Development Goals (SDGs) for 2030 (UN, 2015), includes calls to: (1) improve access to space for all; (2) ensure that all countries benefit socioeconomically from space science, technology applications and data; (3) enable countries to use space to solve everyday challenges; and (4) encourage cooperative partnerships to realise benefits from space (UNOOSA, 2024).

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[1] Declaration on International Cooperation in the Exploration and Use of Outer Space for the Benefit and in the Interest of All States, Taking into Particular Account the Needs of Developing Countries (UNGA, 1996)

African countries are increasingly pursuing space technology applications that impact development objectives, and are united in this pursuit through the AU Commission's African Space Policy and Strategy (AUC, 2019a; 2019b). Space applications that target agricultural productivity are flagged in the Strategy, and by scholars on the continent and development partners, for their potential to, inter alia, catalyse structural transformation while addressing food security and supporting climate-change adaptation (Amusan & Oyewole, 2023). Space applications already have a proven record of strengthening food security analysis through mapping of agriculture and pastoral systems (SDG 2); enhancing climate monitoring and disaster response (SDG 13); and supporting land management by identifying deforestation and ecosystem degradation (SDG 15) (Abbas et al., 2025). Space applications are also being used to document conflict-related environmental damage and rights abuses, thus contributing to accountability and stronger institutions (SDG 16) (UN, 2025). The African Space Agency (AfSA), inaugurated in 2025, has the mandate to coordinate and implement the African Space Strategy and the continent's wider space ambitions (AfSA, n.d.).

## D. African Investment in Space and Early Impacts on Agricultural Outcomes

African nations are making significant efforts towards use and development of space technologies. In 2025, African countries' projected investment in application of space technologies totalled USD426 million (Ritchie, 2025). Among the most active countries in SSA are South Africa, Nigeria, Kenya, Ethiopia, and Rwanda. South Africa operates multiple Earth observation (EO) satellites and has strong domestic data-analytics capabilities and university programmes that support space research, including a CubeSat programme (SANSA, 2022). In 2023, South Africa launched EOS SAT-1, the first in a constellation of satellites said to be "the world's first agriculture-focused satellite constellation" (DSI, 2023) and designed to support agricultural sustainability and monitoring of forestland (Dragonfly Aerospace, n.d.).

Nigeria's space activities are coordinated through its National Space Research and Development Agency (NASRDA), which has, over the past 25 years, overseen the launch of numerous EO satellites for crop monitoring and flood assessment, thus aligning Nigeria's space programme with the country's Support to Climate-Smart Agriculture for Development (Agri-CADE) national action plan (Adepoju, 2025). Kenya has a domestically built satellite (Taifa-1) that supports precision agriculture, pastoral early-warning systems, and crop-insurance analytics (Kenya Space Agency, n.d.; Masila, 2023). Ethiopia has a dedicated Space Science and Geospatial Institute (SSGI) and deploys satellites that support food-security modeling and irrigation-planning in drought-prone areas (SSGI, n.d.). Rwanda, though it does not have a satellite of its own, has recognised space as a leapfrog-technology domain, and leverages high-frequency satellite images and drone imagery for precision agriculture through technology-transfer partnerships that include capacity-building (TIAL, 2025). Collectively, these African national programmes show a readiness to build capacity and to scale local innovation on the ground by leveraging a view from the top.

The impact of space investments on agriculture in African settings are being captured in the scholarly literature. A two-year study in Western Kenya, period satellite data was found to reliably estimate yield in smallholder plots, thus offering opportunities for targeted interventions in support of smallholder farmers (Burke & Lobell, 2017). In Senegal, EO data was combined with climate data as part of a machine learning model to more accurately predict yields of staple crops (maize, millet, sorghum and peanut crops) (Sarr & Sultan, 2022). A study by Nakalembe et al. (2025) reviewed open-access EO systems for applicability in monitoring and forecasting, and found that space-based data can be integrated into national and regional monitoring frameworks and inform policy decisions. At the same time, however, the study found that barriers to adoption remain, including investment, integrating workflows to make EO data relevant for farmers and policymakers, and instances of poor internet connectivity hindering data processing (Nakalembe et al., 2025). A review across 73 low and lower-middle income countries of 268 crop-yield monitoring studies that used EO data (2012-2022) showed that EO is a “crucial decision support tool” for agriculture and food security (Li et al., 2026). However, the study flagged an issue with reliance on open-access medium and low-resolution data (e.g. MODIS, Landsat and Sentinel-2), which, while freely available, often fail to fully capture heterogeneity of smallholder fields. Other studies, including a 30-year review of remote sensing applications for agriculture in Ghana (including EO data) noted that technological uptake by users remains a barrier, and that insights derived from space-based data need to be user-friendly and actionable for small holders (Moomen et al., 2024).

# II. Analysis: Why Now Is the Moment for Space-driven Agricultural Growth

While space technologies are not a panacea for SSA’s development challenges, there is evidence to suggest that they are a uniquely positioned tool for addressing some of the barriers faced by the region’s agricultural sector and to contribute more broadly to advancing the SDGs and individual countries’ development objectives.

### A. Space Technologies Can Improve Productivity

The lack of smallholder productivity gains through adoption of agricultural technology in SSA has been attributed to a range of constraints, including insufficient credit and liquidity; lack of insurance; insufficient technological awareness; high transaction costs due in part to infrastructure gaps; and labour-market and land-market challenges (Suri & Udry, 2022). Space technologies do not remove these constraints, but they do have the potential to mitigate the impacts of some.

One productivity dimension that space technologies can help address is the challenge of managing soil heterogeneity, which is a critical factor in determining crop yield (Oshunsanya et al., 2017). The impact of heterogenous soil conditions can be exacerbated by unequal access to inputs and infrastructure (such as water sources for irrigation), thus making certain farmers highly dependent on local conditions such as rainfall or existing soil nutrients (Oshunsanya et al., 2017).

Data from EO satellites can, importantly, be generated at fine spatial resolutions, allowing for interventions that match the heterogeneity of soil conditions, including moisture and nutrient levels (author’s field study, 2024). Space-enabled precision agriculture can also be used to monitor crop health, and to issue targeted pest and disease warnings. Such warnings can reduce both input costs (as inputs can be applied only where precisely needed), thus helping to improve total productivity and profit, and freeing up labour for other pursuits. According to the World Economic Forum (WEF), precision agriculture can, globally on an annual basis, save up to 800 million tonnes of crops, reduce freshwater usage by up to 2.8 billion litres, and cut CO2 emissions by 50 million tonnes (WEF, 2023).

## B. Space Technologies Can Facilitate Smallholder Insurance

Financial institutions depend on reliable data to design and price agricultural loans and insurance. By improving the accuracy of yield forecasts and assessment of risks (e.g., floods, droughts, pest outbreaks) space technologies can reduce uncertainties that limit access to insurance. For example, an index-based insurance model in Kenya uses satellite data to issue automatic payouts to livestock farmers when pastoral grazing conditions indicate signs of drought (Dror et al., 2015). A 2025 assessment of this insurance scheme found that those subscribed to the programme had increased household income and reduced exposure to downside risk (Shikuku & Ochenje, 2025). There is potential to scale out such uses of space-based data across the continent.

## C. Space-based Data Can Strengthen Policymaking

Policy choices have significant impacts on development outcomes (Beaulier, 2003). Satellite data provides a "30,000-foot view"[2] that can assist decision-makers to make decisions based on insights from real-time data. Canada's Strategy for Satellite Earth Observation adopts a whole-of-society collaboration approach through a policy of "free, open, and accessible data that will enable industry, academia, governments, and Indigenous communities across Canada to benefit from satellite EO" (Government of Canada, 2022). The strategy includes agriculturally focused initiatives such as Canada's Crop Yield Forecaster, as well as broader monitoring of oceans, water quality, greenhouse gas emissions and wildfires. By integrating satellite imaging and geospatial information into planning, governments can better allocate resources and implement policies that support development objectives. For example, satellite data can show regions or crops that are more intensely impacted by climate change, allowing policy actors and implementing institutions to refocus resources and respond to potential food security concerns. In the Common Market for Eastern and Southern Africa (COMESA) region, the satellite-enabled Regional Food Balance Sheet (RFBS) initiative allows for frequent updates, based on digital remote-sensing, of food production forecasts (Chibomba, 2022).

However, while satellite data can be a powerful enabler of improved agricultural-sector policymaking, it is not a substitute for political will or government capacity. For example, floods in Nigeria in 2024 that destroyed over 180,000 farms were preceded by warnings, from the Nigerian Meteorological Agency (NiMET), which were not acted on by national, state and local governments (Iniobong, 2025). Similar warnings generated from satellite data ahead of 2024 floods in Kenya were not headed by smallholders (author's field study, 2024). In addition to public trust, in order for use of satellite technology to take hold and grow to meet local needs, barriers to institutional and commercial uses need to be addressed, including access to finance and to connectivity infrastructure for data-processing (Ferreira et al., 2023).

## D. Technical Cooperation in Space Fits Both African and Donor Objectives

In the African Space Policy of 2019 (AUC, 2019a), African countries have articulated their vision to build capacity and local industry in the space sector. Meanwhile, supporting food security and managing climate change continue to top continental and global policy agendas, including as articulated at the 2025 G20 Summit, hosted by South Africa. At that Summit, G20 Member States explicitly recognised "Africa's vast agricultural potential", encouraging efforts to scale up capacity-building and technical assistance, through digital tools and climate-resilient infrastructure (Government of Canada, 2025b, para. 39).

[2] Most EO satellites are approximately 700-800 km from Earth.

International cooperation that leverages space technology for addressing development challenges such as those posed by food security and climate change is on the rise. The European Space Agency (ESA) was a significant partner in the development of the African Space Agency, and in January 2025 the ESA announced the Africa–EU Space Partnership programme (EC, n.d.). The stated goals of the Partnership are to increase uptake of space-based data; foster institutional and private-sector capacity; and empower African countries to address pressing societal challenges through, inter alia, monitoring environmental changes, strengthening resilience to natural disasters, and deploying advanced early warning systems (EC, n.d.).

Canada is an ESA cooperating state and major contributor. In November 2025, Canada announced an additional CAD528M in funding for ESA programmes including EO and satellite communications, a tenfold increase over previous levels of funding (Canadian Space Agency, 2025). Building on this investment and in alignment with its Africa Strategy, Canada may be poised to contribute to or build off the Africa-EU Space Partnership programme in advancing space for development in Africa, which could reduce risk and administrative burdens associated with new partnerships. Such a coalition could also be an opportunity for the Canadian space sector to co-develop innovative solutions that are commercially scalable across Africa and other regions.

# III. Considerations for Implementation

## A. Factors that May Support Uptake of Space Technologies and Data

Assuming that African and donor governments pursue use of space technologies as part of development strategies to address agricultural productivity, experience to date shows that success can be increased by the presence of certain elements, including: cost- and profit-sharing models involving governments, well-resourced universities with sufficient processing power and high-resolution data, and fair licensing rules for the core assets (data, intellectual property, and labour) (Adebola & Adebola, 2021; author's field study, 2024). National space law and policy, including open data policies, can play an important role in bolstering and de-risking start-up ecosystems.[3] While international partnerships can be a powerful lever for technology transfer, ties between academic institutions and government (including lower-level regional governments which may have closer oversight of agriculture and environment) are important for practical implementation and localization of space-based data solutions (author's field study, 2024).

## B. Opportunities for Reimagining International Cooperation Under Canada's Africa Strategy

Canada's Africa Strategy of 2025 emphasises meaningful partnerships and economic cooperation to address climate, poverty and security (Global Affairs Canada, 2025). Space technology and space-enabled datasets can support these aims. African countries are showing a readiness to build capacity in space-based technology through a pan-African strategy, national investments, and partnerships. Early successes in applying satellite data to address heterogeneity in African agricultural conditions show potential to be further scaled and localised. Canada is well-positioned to respond to calls for technical cooperation through multistakeholder partnerships

[3] For example, Canada's Open Government policies increased access to RADARSAT data that supported innovation in Earth observation analytics, natural resource monitoring, and remote applications in climate-vulnerable Arctic communities. Developing countries such as India have also increased private-sector access to space data, leading to a growth in domestic companies and private investment.

involving governments, space companies and universities, thereby strengthening African institutional capacity and supporting future trade, security, and cooperation in multilateral fora.

Practically, Canada can offer its technical experience gained through satellite programmes such as RADARSAT/RADARSAT2 (used for environmental monitoring and resource management) and the Canadian Ag-Land Monitoring System (CALMS), as well as its Strategy for Satellite Earth Observation based on open data principles. Canadian companies have also mounted initiatives to provide open access to high-resolution data, with the aim of supporting humanitarian initiatives and environmental monitoring (Wyvern, 2025). Canada can help broker partnerships between academic institutions and start up ecosystems in Africa for capacity building and sustained access to such high-resolution datasets. Canada's participation and recent investment in ESA also provide a potential platform to deepen cooperation with African countries, given ESA's historic support for African space capabilities. Such cooperation would allow Canadian capabilities to be showcased and refined for future buyers in Africa, including the African Space Agency, national space agencies, and private companies. Initial focus on countries such as South Africa, Kenya, Ethiopia and Rwanda, which display a readiness for capacity development and integration of space-based data across institutions (in agriculture, climate mitigation, and beyond), could yield successful partnerships.

# IV. Conclusion

> Looking at the earth from afar you realize it is too small for conflict and just big enough for co-operation. (Gagarin, 1961)

These words from the first human in space, cosmonaut Yuri Gagarin, remind us that a view from the cosmos spotlights the interconnected nature of humanity's home and the need to cooperate in order to solve persistent and emerging development challenges. Adoption of space technologies, including EO satellites and space data applications, can help African economies, particularly in SSA, to overcome longstanding barriers to agricultural productivity. By raising productivity levels, structural economic change can be catalysed, unleashing the power and potential of the world's youngest continent and labour force. In addition to boosting the agricultural sector, space data can support multiple UN SDGs and address a range of challenges resulting from climate change. Canada is well-positioned to partner with African countries on space-technology deployments and policy development, bilaterally or through the existing Africa-EU Space Partnership, in a new era of cooperation that goes beyond ODA.

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