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Leveraging the Potential of Crop Mapping for Improved Decision-Making Under the Kampala Declaration

By Jean Paul Latyr Faye and Aissatou Ndoye

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Editorial

Since its adoption by the African Union (AU) in 2003, the [Comprehensive Africa Agriculture Development Programme](#) (CAADP) has been Africa's primary policy framework for agricultural transformation, wealth creation, food security, economic growth, and prosperity. It guides the African Union Commission (AUC), the African Union Development Agency-New Partnership for Africa's Development (AUDA-NEPAD), Regional Economic Communities (RECs), and Member States in driving agricultural transformation toward a self-reliant and productive Africa.

The [Kampala CAADP Declaration](#) on “**Building Resilient and Sustainable Agrifood Systems in Africa**” and the associated [CAADP Strategy and Action Plan \(2026-2035\)](#) will build on the success and deepen the progress achieved after two decades of CAADP implementation, during which Africa significantly improved in economic and agricultural growth, poverty reduction, nutrition outcomes, and agricultural trade expansion. The next 10-year cycle of CAADP implementation must further deepen its focus by incorporating lessons learned and responding to emerging challenges to accelerate sustainable agrifood systems transformation in the context of climate change and multifaceted stressors and shocks.

The longevity and continued success of CAADP can be attributed to its legitimacy as a shared framework that guides Member States toward agricultural transformation and economic growth. Guided by CAADP principles and values, particularly African ownership and mutual accountability, and strengthened through review and benchmarking mechanisms, data and analytics have been central to CAADP's evidence-based planning and implementation. As Africa embarks on the implementation phase of the Kampala CAADP Declaration, which took effect on January 1, 2026, evidence and robust data analysis will remain indispensable to successful on-the-ground implementation. This is the rationale behind AKADEMIYA2063's Kampala Policy Brief Series.

The policy briefs serve as reference documents for policy analysts and planners across AU Member States as they prepare their programs in response to the Kampala CAADP Declaration. The series provides a synthesis of a large body of research addressing topics of strategic relevance to Africa's development agenda, alongside key issues to be tackled during the new phase of CAADP implementation, with the aim of generating insights, examining emerging ideas, reviewing crosscutting thematic areas, and proposing policy recommendations that can be adapted and replicated for sustainable impact.

The evidence presented in the Kampala Policy Brief Series draws on published research and data from AKADEMIYA2063's scientists and collaborators across Africa and beyond. These lessons are made accessible to policymakers, non-state actors, practitioners at continental, regional, and national levels, and development partners to support the implementation of CAADP 2026-2035. In addition to packaging the lessons and insights into comprehensive yet accessible knowledge products, AKADEMIYA2063 facilitates policy dialogue through webinars. During these sessions, the findings are presented to a broad range of stakeholders to inform programmatic interventions that support the implementation of the Kampala CAADP Agenda.

Executive Summary

The Kampala CAADP Declaration commits African nations to transform agrifood systems through innovation, climate resilience, and data-driven policy (AUC and AUDA-NEPAD 2025a). Its bold targets include boosting output by 45 percent and strengthening early warning and sustainable practices. Achieving these goals requires timely, granular agricultural data, which represents a critical gap in many African countries.

This policy brief supports CAADP's vision by demonstrating how modern satellite imagery and Artificial Intelligence (AI), specifically machine learning, can generate crop maps that fill data gaps across diverse fields. Crop type maps provide critical insights into the spatial distribution of crops and serve as a foundation for a wide range of agricultural monitoring applications. These include early warning systems for crop failures, assessments of crop suitability, crop health and condition, yield forecasting, and evaluations of damage caused by extreme weather events. In addition, crop maps support the generation of agricultural statistics, inform agricultural insurance schemes, and contribute to climate change mitigation and adaptation strategies. The crop maps and analyses thus offer national planners new evidence to guide investment, adaptation, and agri-policy under the CAADP Strategy and Action Plan (2026-2035) (AUC and AUDA-NEPAD 2025b).

We used 10-meter resolution Sentinel-2 satellite imagery and supervised machine learning (ML) classifiers, including random forest, support vector machine, and neural networks, to identify groundnut fields in the Senegalese Basin. These models were trained on ground-truth field data collected during AKADEMIYA2063's DERPin project¹. Among the machine learning algorithms tested, the Random Forest model achieved the highest accuracy, reaching up to 83 percent on held-out test plots, demonstrating strong reliability in crop-type classification. We have adopted a new approach called probabilistic crop type mapping. It allows improvement in the model's prediction accuracy and the incorporation of uncertainties and variability.

In addition, this approach is well-suited for African farming due to the complexity of smallholder farming systems and the variability in field sizes and shapes. The approach also enables stakeholders and policymakers to make better-informed decisions based on the level of precision needed for their specific requirements. It is well-known that outputs with higher probabilities lead to more accurate decisions.

The main outcome of this study is the generation of a high-resolution crop map for groundnuts, which shows a sharp decline in cultivated area over time. In 2018, groundnuts covered approximately 536,642 hectares in the Groundnut Basin, down from 494,843 hectares in 2023, a decrease of 7.8 percent. While several factors may have contributed to this reduction, climate change is recognized as a major driver of the decline.

Detailed crop maps provide policymakers with accurate, subnational data essential for informed planning. They help close the persistent gap in reliable planting-area statistics across many regions. By revealing where and how cropping patterns are shifting, these maps improve production forecasting and strengthen early warning systems. For instance, the observed decline in groundnut cultivation underscores the need to support farmers' adaptation efforts, such as introducing drought-tolerant crop varieties and diversifying income sources.

Recommendations for policymakers include increasing investments in national-scale data collection initiatives to support the development of robust crop-mapping systems that integrate field data, satellite imagery, and AI; integrating these maps into agricultural monitoring and early warning systems to advance CAADP pillars focused on climate resilience and technological innovation; and leveraging crop maps to inform sustainable intensification and climate-smart agricultural practices. To maximize impact, it is essential to strengthen national capacity in geospatial analysis, enabling governments to effectively monitor progress toward CAADP targets for productivity and food security.

¹ The Digitally Enabled Resilience and Nutrition Policy Innovations (DERPin) project seeks to strengthen agrifood systems policies and strategies in Africa by increasing access to the evidence needed to guide better-informed decision-making. DERPin is funded by the German Federal Ministry for Economic Cooperation and Development (BMZ) and implemented by AKADEMIYA2063 on behalf of Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

1.Introduction

Africa's population is expected to rise dramatically in the coming decades, reaching roughly 2.5-2.6 billion by 2050 (Golden 2023; Tabutin and Schoumaker 2020), putting agrifood systems under pressure and demanding new approaches to sustainable agriculture. Data-driven solutions play a critical role in agricultural decision-making. However, in many African countries, agricultural data, such as crop locations, are often outdated because they are typically collected through traditional ground surveys. These methods are slow, costly, and difficult to implement across large, diverse areas dominated by smallholder farming. As a result, governments often lack accurate figures on crop areas, undermining production estimates and evidence-based policy planning. This challenge is further intensified by the impacts of climate change. Satellite remote sensing combined with AI offers a powerful solution to these data gaps. Crop type maps provide critical insights into the spatial distribution of crops and serve as a foundation for a wide range of agricultural monitoring applications. These include early warning systems for crop failures, crop suitability assessments, assessments of crop health and condition, yield forecasting, and evaluations of damage caused by extreme weather events. In addition, crop maps support the generation of agricultural statistics, inform agricultural insurance schemes, and contribute to climate change mitigation and adaptation strategies. For policymakers, access to timely crop maps is essential for planning irrigation strategies, targeting input subsidies, implementing effective climate adaptation measures, and introducing new technologies.

2. Statement of the Research Problem

Agriculture remains the backbone of most African economies, providing livelihoods for the majority of the population and serving as a critical engine for food security, trade, and rural development. Despite its importance, detailed, crop-specific land-use data remain scarce across the continent. Many countries lack regularly updated, high-resolution digital crop maps, severely limiting the capacity to monitor agricultural performance, track seasonal trends, or design and implement targeted, data-driven interventions.

This data gap is particularly evident in Senegal's Groundnut Basin, one of West Africa's most vital agro-ecological zones. Groundnut serves as both a staple food crop and a key source of household income, yet current information on its spatial distribution and acreage is outdated or unavailable. National statistics, often based on coarse administrative reporting or limited field surveys, tend to misestimate actual planted areas, obscuring the true dynamics of agricultural production on the ground.

This lack of granular data undermines evidence-based policymaking, weakens the effectiveness of extension services, and limits the design of effective responses to climate shocks, pest outbreaks, and market fluctuations. Furthermore, it hinders efforts to assess compliance with national targets under the CAADP and with emerging digital agriculture strategies advocated in the Kampala Declaration.

This brief addresses the problem by combining state-of-the-art remote sensing technologies with AI to generate accurate, up-to-date crop-type maps, with a focus on identifying groundnut cultivation patterns at the field level. By leveraging Sentinel-2 satellite imagery, vegetation indices, and advanced machine learning algorithms, the brief produces spatially detailed, scalable crop maps that can be used to support a wide range of applications, from early warning systems and crop monitoring to input targeting, insurance design, and climate adaptation planning.

By closing this data gap, the brief contributes directly to the Kampala Declaration's pillars on digital agriculture, early warning systems, and climate-resilient agrifood systems, providing a model that can be scaled and adapted across other African agricultural regions.



3. Enhancing Crop Classification Accuracy with Probabilistic Machine Learning Approaches



Traditional satellite-based crop classification methods using machine learning typically focus on predicting the most likely crop class for each pixel. While this approach has produced valuable results globally, it falls short in the African context. The complexity of smallholder farming systems, characterized by diverse cropping patterns, irregular field shapes, and small plot sizes, reduces the effectiveness of conventional models. Moreover, these methods often fail to capture classification uncertainty, particularly when dealing with limited spectral resolution or crops with similar reflectance signatures, as is common across many African landscapes. These limitations highlight the need for more adaptive, probabilistic approaches that align with the realities of African agriculture and support the goals of the Kampala Declaration.

In line with the objectives of the Kampala Declaration, this brief introduces a new strategy: probabilistic crop type mapping. It retains and analyzes the full range of class probabilities, thereby enhancing the accuracy and reliability of crop classification. This probabilistic framework enables more nuanced interpretation of satellite data, identifies areas of classification uncertainty, and allows integration with complementary sources such as ground surveys or temporal crop signatures. The result is more precise, data-driven, and actionable crop distribution maps that support evidence-based decision-making for resilient and inclusive agricultural systems across Africa.

4. Steps to Probabilistic Crop Mapping

Crop-type mapping primarily involves three steps: field data collection, satellite data acquisition, and vegetation index evaluation. These steps are followed by the application of machine learning techniques to analyze the data and generate detailed, accurate crop-type maps.

4.1. Field data collection

As part of efforts to strengthen data-driven agriculture in line with the Kampala Declaration, field data collection was conducted during the June to September 2023 agricultural season in Senegal's Groundnut Basin. The survey focused primarily on groundnut, alongside other crops such as maize and millet. Using a one-round data collection approach, 325 crop plots were mapped via field surveys. Field teams documented crop types directly in the field, enabling precise spatial analysis. Although the phenological stages of the crops were not recorded due to the single-round collection, this integrated approach enabled detailed mapping, including identification of intercropped fields, where multiple crops were cultivated simultaneously. This combination of ground and aerial data sources provided a robust foundation for training machine learning models and producing reliable crop type maps.

Given the heterogeneous and small-scale nature of agriculture in Africa, especially in regions like the Groundnut Basin, images with a spatial resolution of 10 meters (a pixel size of 100 m²) are essential for distinguishing fragmented crop plots. For this study, we selected Level-2A Sentinel-2 images, which provide top-of-canopy reflectance values and cloud masking. To ensure data quality, only images with less than 5 percent cloud cover were retained.

4.1. Vegetation index evaluation

In our approach, we integrated key vegetation indices derived from the core optical bands (Blue, Green, Red, and Near-Infrared) to enrich the machine learning model for crop type mapping. Among them, the Normalized Difference Vegetation Index (NDVI) is a foundational tool for monitoring vegetation health and dynamics and strongly correlates with parameters such as leaf area and chlorophyll concentration. However, NDVI alone may not fully capture the complexity of crop phenology, pigment variations, or soil and water conditions, especially in diverse farming systems. To address these limitations, we used a suite of complementary vegetation indices, such as the Soil-Adjusted Vegetation Index (SAVI) and the Wide Dynamic Range Vegetation Index (WDRVI), each offering unique insights into crop growth stages, water stress, and canopy structure. These indices strengthen the capacity for accurate, timely, and context-specific crop monitoring.

4.1. Satellite data acquisition

To support accurate and scalable probabilistic crop mapping, this brief relies on open-access Earth observation data, with imagery sourced from the Sentinel-2 satellite, part of the European Copernicus program (Jutz and Milagro-Perez 2020). Sentinel-2 provides high-quality, multispectral images at spatial resolutions of 10, 20, and 60 meters, with a temporal revisit frequency of 2-5 days, making it well suited for monitoring agricultural dynamics.

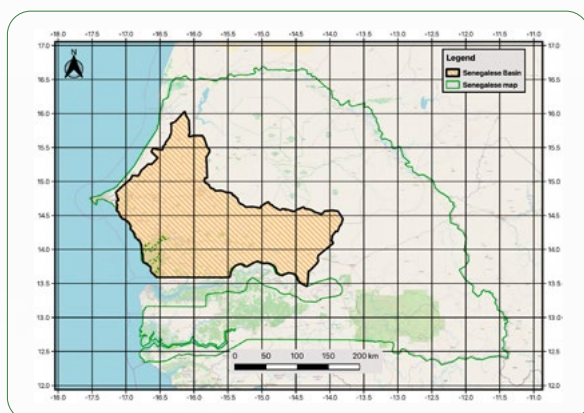
5. Analysis and Findings

Using labeled ground-truth data alongside vegetation indices and spectral bands, we trained three machine learning classifiers, random forest, support vector machine, and neural network (Nitze, Schulthess, and Asche 2012), to differentiate groundnuts from other crops. Among these, the random forest model achieved the highest accuracy, correctly classifying over 83 percent of the test plots. Indeed, among machine learning algorithms applied to crop type mapping, random forest has consistently performed well because of its robustness, interpretability, and ability to handle high-dimensional, noisy data common in remote sensing applications. Compared to support vector machines, which are effective for binary classification but often struggle with multi-class and large-scale datasets, random forest offers better scalability and reduced sensitivity to parameter tuning. Convolutional neural networks, while powerful in capturing spatial and temporal patterns, typically require large labeled datasets and extensive computational resources, making them less accessible for projects with limited ground-truth data or processing capacity.

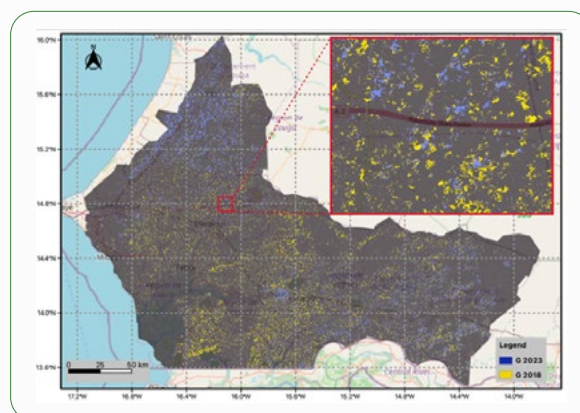
On the other hand, XGBoost, a gradient boosting algorithm, often achieves higher accuracy than random forest on structured data but can be more prone to overfitting and less interpretable without careful tuning. Thus, in many real-world crop mapping scenarios, especially those involving moderate training data sizes, mixed data quality, and multiple crop classes, random forest strikes an effective balance between performance, stability, and ease of use, making it a preferred baseline model for operational applications and scalable deployments. For these reasons, we have applied the random forest model to satellite imagery covering the entire Groundnut Basin, resulting in detailed maps of groundnut cultivation areas. Figure 1 compares groundnut cultivation in 2018 (blue) vs. 2023 (yellow). The difference is shown in red. The study finds that groundnut area fell sharply by 7.8 percent over the five years. In 2018, about 536,642 ha were under groundnut, declining to 494,843 ha by 2023. The groundnut map reveals important statistics: it quantifies groundnut extent, highlights geographic patterns, and measures change. Importantly, it transforms raw satellite data into actionable intelligence.

Figure 1. Groundnut cultivation areas in Senegal.

Area of interest



Groundnut Basin for 2018 (blue) vs. 2023 (yellow)



Source: Authors.

Note: Areas in red were planted with groundnut in both years. The total planted area fell by up to 7.8 percent from 2018 to 2023.

Thus, the crop map offers detailed insights into evolving groundnut farming patterns and can inform better policies and climate-adaptation strategies. It can also serve as a starting point for agronomists and researchers to investigate the underlying causes of observed declines, while providing policymakers with the evidence needed to develop appropriate and timely responses. The analysis that informed this brief can be scaled to other African countries to support CAADP's call for evidence-based planning and resilient agrifood systems.



6. Policy Lessons and Recommendations

Crop maps are essential decision-support tools for policymakers. They provide the foundation for a wide range of applications, including early warning systems to anticipate crop failures, assessments of suitable zones for different crops, monitoring of crop health and condition, yield forecasting, and evaluation of damage caused by extreme weather events. By providing timely and spatially explicit information, crop maps enable policymakers to design evidence-based interventions, allocate resources more efficiently, and strengthen resilience in the agricultural sector.

Scale up crop-mapping capacity: Scaling up national crop-mapping capacity requires a mix of investment, skills, and institutional commitment: ministries need sustained funding to access and process satellite imagery, maintain computing infrastructure, and support field data collection; technical teams must be trained in remote sensing, AI, agronomy, and survey design to generate accurate, validated maps; and governments must embed these methods in their statistical and agricultural systems through standards, interagency coordination, and data-sharing frameworks. Partnerships with universities, extension services, and private providers are essential for building ground-truth datasets and ensuring technology transfer, while regional and continental collaborations can reduce duplication and align with CAADP priorities. Ultimately, routine crop mapping depends not only on tools but also on building local capacity, knowledge, and governance systems so that high-resolution maps directly inform food security monitoring, climate adaptation, and evidence-based agricultural planning.

Integrating crop map tools into decision-making systems: Governments should mandate real-time crop mapping within early warning systems, invest in data infrastructure, and build capacity for timely response. The private sector can use these tools to improve yield forecasts, supply chains, and climate-smart insurance products, while co-financing innovations. Development partners and research institutions should provide technical support, promote interoperability, and encourage

open data to enable regional collaboration. Coordinated action, sustainable financing, and capacity building are essential to translate crop mapping insights into effective responses that strengthen food security and resilience, in line with CAADP's focus on resilient food systems.

Guide sustainable intensification: Detailed maps help target interventions, allowing extension services or subsidy programs to be directed to underperforming zones. Policymakers can use spatial data to allocate investments where they can close yield gaps.

Build digital agriculture frameworks: National strategic plans for digital agriculture should systematically integrate geospatial data and AI as foundational tools for sectoral transformation. Embedding these technologies within policy frameworks will strengthen agricultural monitoring, enable more accurate productivity forecasting, and enhance adaptive responses to climate variability. Developing national expertise in remote sensing and machine learning is essential to ensure local ownership, reduce dependency on external support, and build the institutional capacity needed to apply these methods at scale across the continent.

The present juncture offers a strategic opportunity to anchor these priorities within countries' ongoing domestication and implementation of regional and global frameworks. Ensuring alignment between national digital agriculture strategies and broader commitments will foster policy coherence, facilitate resource mobilization, and accelerate the deployment of proven solutions. Institutionalizing geospatial and AI-driven approaches in this way will position countries to fully harness digital transformation to support sustainable, climate-resilient, and inclusive agricultural development.

In summary, crop mapping is a powerful policy instrument that can equip African countries to make informed decisions, ranging from climate adaptation to food-security planning, ensuring that agricultural investments deliver sustainable outcomes and reinforce CAADP's smart-agriculture objectives.

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ABOUT AKADEMIYA2063

AKADEMIYA2063 is a pan-African non-profit research organization with headquarters in Kigali, Rwanda, and a regional office in Dakar, Senegal. Inspired by the ambitions of Agenda 2063 and grounded in the recognition of the central importance of strong knowledge and evidence systems, the vision of AKADEMIYA2063 is an Africa with the expertise we need for the Africa we want. This expertise must be responsive to the continent's needs for data and analysis to ensure high-quality policy design and execution. Inclusive, evidence-informed policymaking is key to meeting the continent's development aspirations, creating wealth, and changing livelihoods for the better. AKADEMIYA2063's overall mission is to create, across Africa and led from its headquarters in Rwanda, state-of-the-art technical capacities to support the efforts of the Member States of the African Union to achieve the key goals of the African Union's Agenda 2063: transforming national economies to boost growth and prosperity. Following from its vision and mission, the main goal of AKADEMIYA2063 is to help meet Africa's needs at the continental, regional, and national levels in terms of data, analytics, and mutual learning for the effective implementation of Agenda 2063 and the realization of its outcomes by a critical mass of countries. AKADEMIYA2063 strives to meet its goals through programs organized into five strategic areas—policy intelligence, knowledge systems, data intelligence and governance—as well as partnerships, and communications and outreach activities. For more information, visit www.akademiya2063.org.



Building Resilient and Sustainable Agrifood Systems in Africa



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