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A Continental GeoAI Architecture for Climate-Resilient Food Systems in Africa

By Khadim Dia, Racine Ly, and Mansour Dia

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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

Africa's food systems face a combination of pressures from climatic volatility, demographic change, land degradation, and market interdependence. The Kampala CAADP Declaration seeks to consolidate these pressures into a coherent continental response supported by the transformative potential of artificial intelligence (AI) and geospatial intelligence. The ambition is not merely to improve climate monitoring or strengthen agricultural management; it is to create an integrated continental intelligence architecture capable of anticipating shocks, guiding decisions, stabilizing markets, and measuring adaptation with a level of precision Africa has not had before.

This policy brief uses Senegal's 2025 season analysis to demonstrate how GeoAI can support the implementation of the Kampala commitments by providing context-specific, subnational intelligence.

This brief aims to demonstrate how GeoAI can guide actions toward achieving the Kampala commitments and vision, and to advocate for a continental GeoAI architecture that supports Member States in implementing context-specific, subnational policy actions. The Senegal example is presented not as an isolated national assessment but as a concrete illustration of a continental capability that AKADEMIYA2063 has already developed for multiple African countries. Through this demonstration—rich in climatic indicators, vegetation dynamics, and AI-based production forecasting—the brief shows how GeoAI can form the operational backbone of the Kampala CAADP Agenda. The subsequent sections highlight the mechanics of these analytics, their policy implications, and their significance for a continental approach to resilience (AKADEMIYA2063 2024; Ly, Dia, and Diallo 2021).



1. The Kampala CAADP Agenda in a Transforming Continental Digital Landscape

The Kampala CAADP Agenda emerges amid profound shifts across Africa. Climate shocks are increasingly frequent and severe, affecting rainfall patterns, evapotranspiration cycles, soil moisture dynamics, and ultimately crop yields. These biophysical shifts destabilize livelihoods, disrupt food markets, and compound vulnerabilities in regions where smallholder agriculture remains the primary livelihood. At the same time, technological innovation—particularly in AI, Earth Observation, and data integration—is creating new possibilities for predictive governance and anticipatory action (AUC and AUDA-NEPAD 2025a).

The Kampala CAADP Agenda is expected to align with existing continental frameworks, including Agenda 2063, the African Union Digital Transformation Strategy, and the African Continental Free Trade Area (AfCFTA). What distinguishes it is its forward-looking emphasis on digital capability as a foundation for resilience. It proposes to move beyond fragmented national efforts toward a continental intelligence environment capable of observing climatic patterns, detecting early warning signals, and coordinating decision-making across borders. The early contours of the Agenda point toward a unified vision in which data flows across regions, Regional Economic Communities (RECs) coordinate responses across agroecological zones, national systems draw on interoperable platforms, and continental institutions provide guidance anchored in real-time geospatial intelligence (AUC and AUDA-NEPAD 2025a; AUC and AUDA-NEPAD 2025b; AUC 2015, 2018, 2020).

Such a transformation requires more than declarations; it requires a digital backbone that translates climatic, agronomic, and market signals into actionable evidence. GeoAI is relevant in this context because it can integrate multiple streams of information—temperature, rainfall, vegetation, soil response, and forecast outputs—into decision-ready analytics that support both short-term response and longer-term resilience planning (Boutayeb, Lahsen-Cherif, and El Khadimi 2025; Espinel et al. 2024).



2. AI and Geospatial Intelligence as the Operational Foundation of the Kampala CAADP Agenda

AI fed by Earth Observation data can enable African policymakers to see, measure, and interpret climatic and agricultural conditions with unprecedented granularity. What once required long field campaigns, scattered reports, and delayed national statistics can now be understood at the scale of days and kilometers. The integration of land-surface temperature anomalies, rainfall distribution patterns, Normalized Difference Vegetation Index (NDVI) vegetation dynamics, and hydrological indicators offers a multidimensional picture of conditions on the ground (AKADEMIYA2063 2024; Heiss et al. 2025).

Crucially, the value of these data lies not merely in their presence but in their convergence. When combined, they reveal relationships that single indicators cannot capture, such as how a drop in rainfall interacts with thermal load to affect grain filling; how a neutral NDVI mask can mask earlier reproductive stress; how short dry spells can undermine flowering even when total rainfall appears normal; or how soil texture and landscape position modulate the effects of climatic anomalies (Heiss et al. 2025).

This is where AI becomes decisive. AI-driven models can translate climatic and biophysical signals into actionable forecasts, estimating production outcomes long before harvest and revealing emerging vulnerabilities weeks in advance. Such predictive capability enables national and regional actors to be proactive and respond to signals before they materialize into a crisis (Boutayeb, Lahsen-Cherif, and El Khadimi 2025).

In this sense, GeoAI should be understood not as a substitute for existing agrifood governance systems but as an enabling layer that strengthens implementation of the Kampala CAADP Agenda. Predictive intelligence and high-resolution geospatial monitoring provide practical tools for targeting interventions, differentiating risk across locations, and linking continental objectives to operational decisions on the ground.



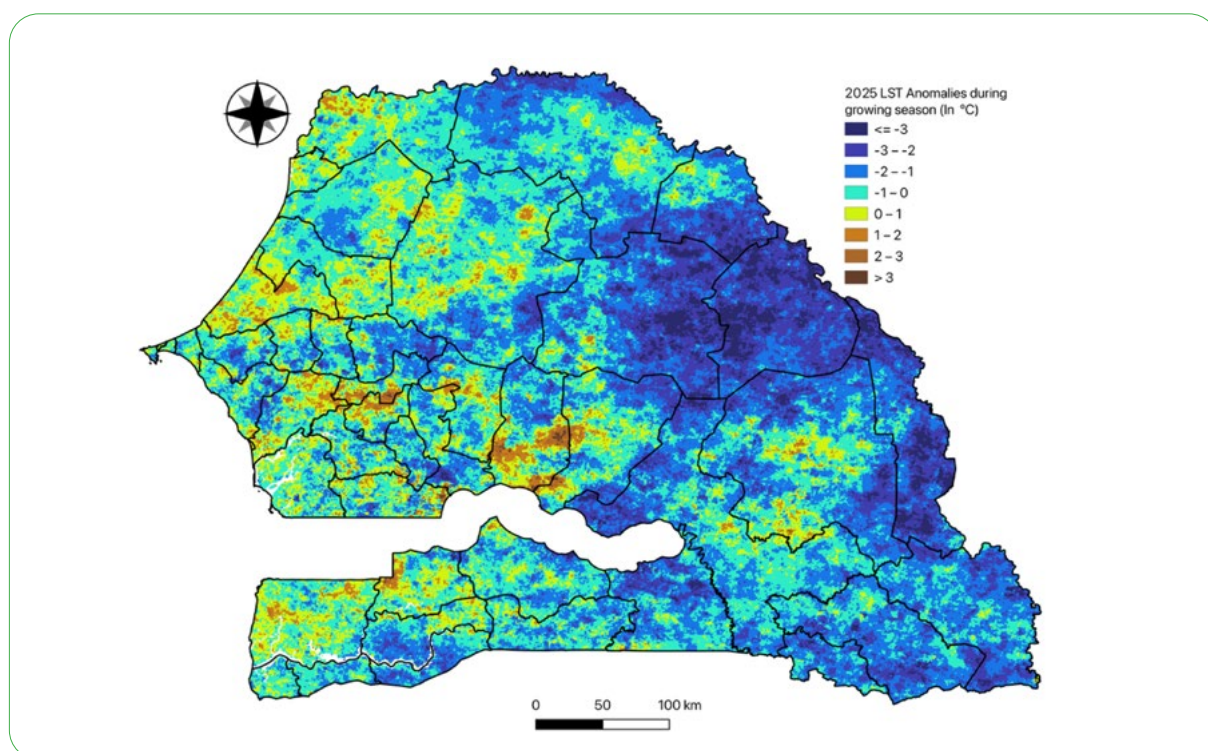
3. The Use of GeoAI for Guiding Climate Actions: the Case of Senegal

Although the analytical example comes from Senegal, the GeoAI systems that generate these insights are continental in scope, designed and maintained by AKADEMIYA2063, and implemented across multiple regions of Africa. Senegal is therefore best understood as a demonstration of a much larger capability: the continental geospatial analytics infrastructure that can underpin climate action under the Kampala Agenda (AKADEMIYA2063 2024; Ly, Dia, and Diallo 2021).

3.1. Climate Anomalies: Understanding the Spatial Logic of Risk

The 2025 season across Senegal revealed spatially diverse climatic conditions that shaped agricultural outcomes at the subnational scale. Land-surface temperature anomalies showed cooler-than-average conditions across extensive northern and eastern zones, providing a more favorable thermal environment for cereals by reducing heat load and slowing evaporative demand. By contrast, warmer conditions in parts of the west—notably the western littoral and portions of the central Peanut Basin—were associated with higher vapor-pressure deficits and shorter crop development windows. These contrasts are partly linked to differences in coastal influence, land-surface characteristics, vegetation cover, and moisture availability, which shape how thermal stress is expressed across space (Figure 1).

Figure 1. Land Surface Temperature anomalies in Senegal for the year 2025 and during the agricultural growing season (June–August 2025).



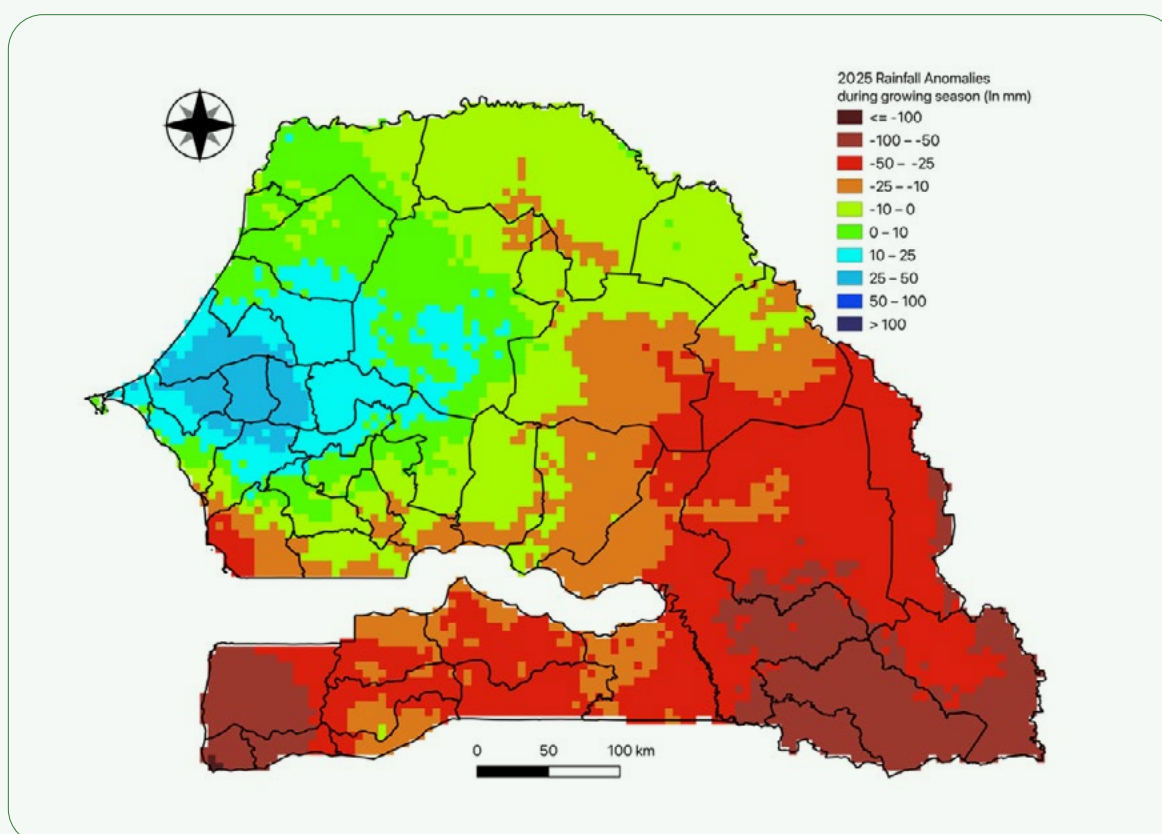
Source: Authors' calculations based on MODIS Land Surface Temperature (LST) data, processed through Africa Agriculture Watch (AAGWa), AKADEMIYA2063.

Note: Anomalies are calculated relative to the mean land surface temperature for the corresponding period during 2020–2024.

These patterns are emblematic of broader continental dynamics in which thermal stress and rainfall variability combine to create localized risk pockets. For policy purposes, such pockets can be characterized by a set of indicators: persistent heat anomalies, rainfall deficits or poor intra-seasonal distribution, weak vegetation response, and historically low production performance. Framing them this way helps shift from descriptive maps to operational targeting of advisory support, input allocation, contingency planning, and resilience investments.

Rainfall anomalies added another layer of complexity, with the 2025 season showing widespread deficits across the southern and southeastern parts of Senegal, juxtaposed with localized surpluses in some northern and central areas (Figure 2). However, the interaction between seasonal totals and storm timing was more decisive than rainfall volume alone; in Senegal, as in many African regions, short dry spells around critical phenological stages such as tasseling or panicle initiation can significantly reduce yield potential even when cumulative rainfall appears sufficient.

Figure 2. Rainfall anomalies in Senegal for 2025 and the agricultural growing season (June–August 2025).



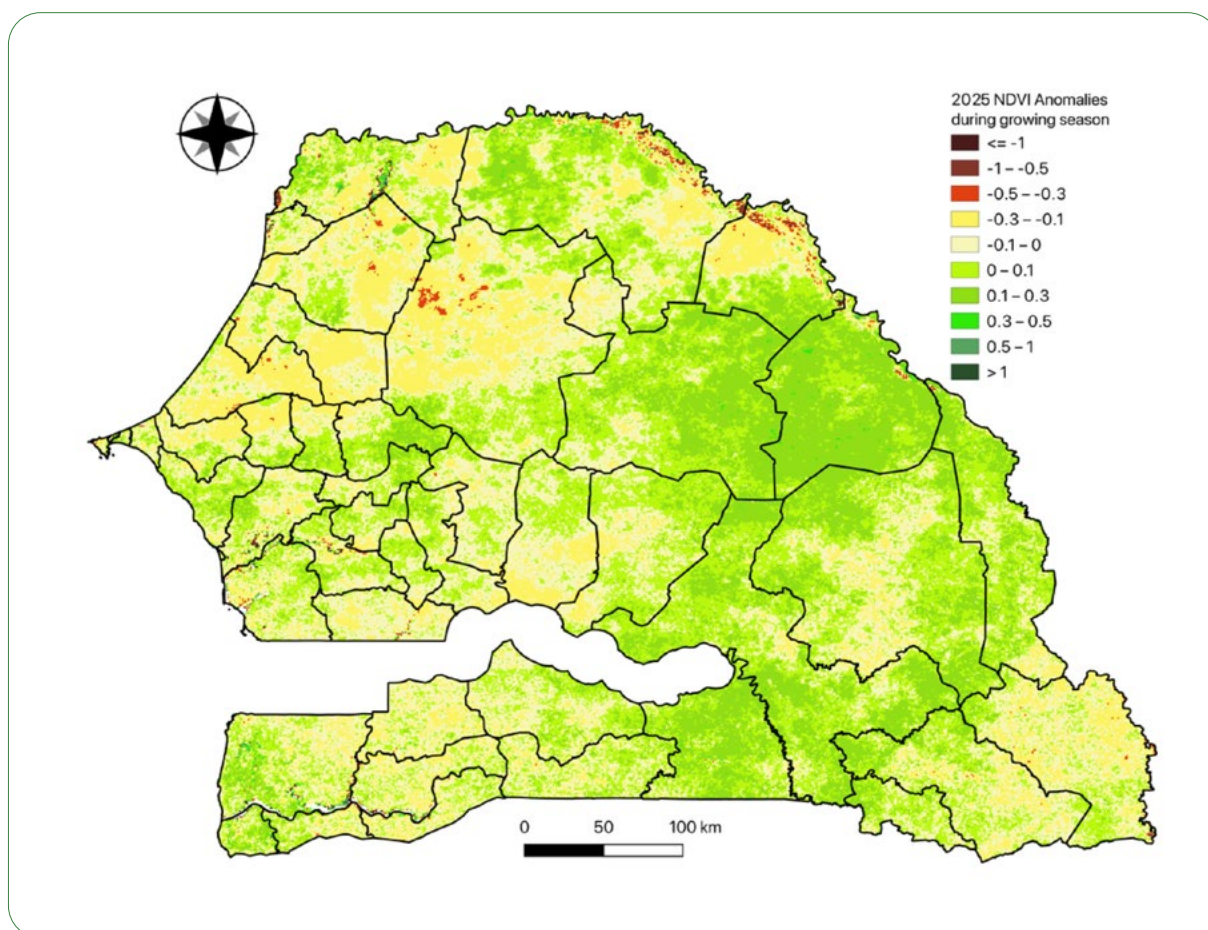
Source: Authors' calculations based on CHIRPS rainfall data, processed through Africa Agriculture Watch (AAGWa), AKADEMIYA2063.

Note: Anomalies are calculated relative to the mean rainfall for the corresponding period during 2020–2024.



Vegetation anomalies derived from NDVI clarified the effects of these climatic interactions. Greener-than-average conditions in eastern and southeastern Senegal indicated that timely rainfall and moderated temperatures supported canopy vigor. Neutral or negative anomalies in the western corridor revealed suppressed leaf area, shorter growing cycles, or earlier stress (Figure 3).

Figure 3. Normalized Difference Vegetation Index (NDVI) anomalies in Senegal for 2025 and the agricultural growing season (June–August 2025).



Source: Authors' calculations based on MODIS Normalized Difference Vegetation Index (NDVI) data, processed through Africa Agriculture Watch (AAgWa), AKADEMIYA2063.

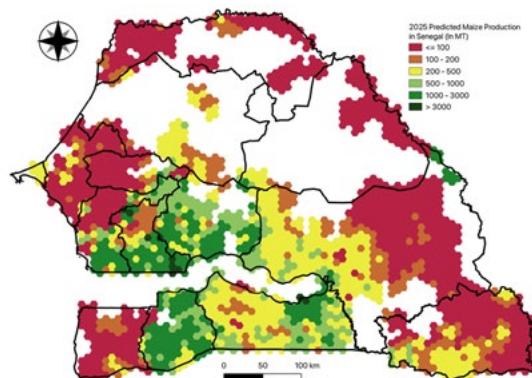
Note: Anomalies are calculated relative to the mean NDVI for the corresponding period during 2020–2024.

These patterns are also observed elsewhere on the continent: areas with stronger vegetation response tend to coincide with more favorable rainfall patterns and moderated temperatures, while areas with weak canopy development often coincide with heat and moisture stress. However, the relationship should be interpreted cautiously, as these factors interact rather than follow a simple one-way causal chain; suppressed vegetation can reflect stress conditions, while reduced canopy cover can in turn amplify surface exposure and heat effects (AKADEMIYA2063 2024; Ly, Dia, and Diallo 2021; Shawon et al. 2025).

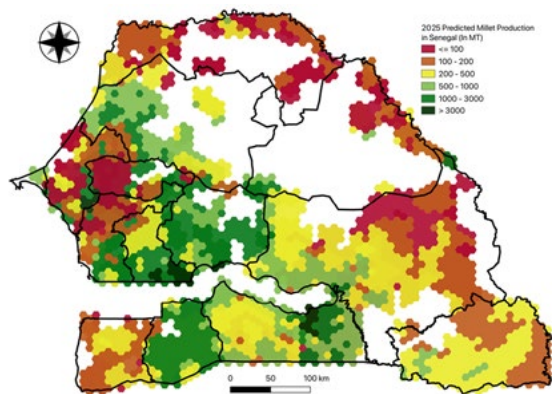
3.2. Production Forecasting: From Climate Signals to Anticipatory Action

The production maps for maize, millet, and sorghum synthesize climatic and vegetation signals into a unified GeoAI-based interpretation of expected outcomes for the 2025 season. These maps translate temperature anomalies, rainfall patterns, vegetation responses, soil moisture conditions, and long-term structural baselines into forward-looking estimates of crop performance across Senegal's agroecological zones. Together, they provide a coherent picture of cereal production dynamics, enabling policymakers to anticipate emerging supply shortfalls, identify potential surplus zones, and plan early interventions in areas where climatic stress is likely to depress yields. The value of these maps lies not only in their spatial precision but also in how they capture the ecological logic of Senegal's agricultural landscape: chronically low-performing western littoral zones, climatically volatile central corridors, and structurally resilient belts across the south and southeast. Presented together, the three maps reveal the shared and crop-specific vulnerabilities that define the 2025 growing season, offering a foundation for targeted advisory services, market stabilization plans, and regional coordination.

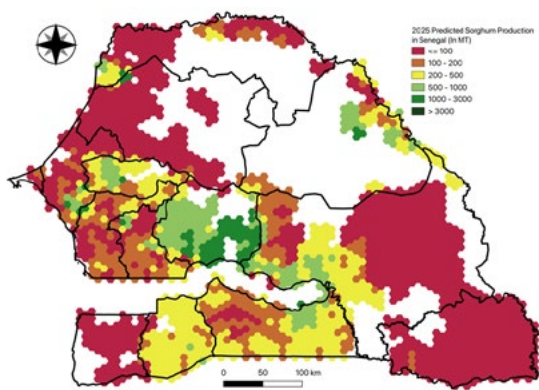
Table 1. GeoAI-based production forecast interpretation for maize, millet, and sorghum in Senegal during the 2025 growing season.



The **maize** forecast reveals a strong north-south gradient. Much of the northern and western zones is expected to produce below 100 tons per cell grid of 10 km, reflecting the impact of early-season heat and moisture stress on pollination and grain set. Production improves across the central corridor, with many areas ranging from 200 to 1,000 tons, supported by better mid-season rainfall pulses. The highest values occur in the south, especially in Kolda and Ziguinchor, where several cells exceed 3,000 tons, driven by more regular rainfall and cooler periods that favored grain filling.



Millet production mirrors the country's agroecological structure. Western littoral areas remain weak, often under 200 tons per cell grid of 10 km, due to sandy soils and disrupted early vegetative growth. Output strengthens progressively eastward, with central departments generally producing 800 to 1,500 tons, anchored in more timely rainfall. Southeastern regions, including Kolda, Sédhiou, and parts of Kédougou, show the strongest performance, frequently exceeding 3,000 tons, thanks to longer growing seasons and fewer heat episodes during heading.



Sorghum forecasts follow a similar spatial pattern, with most western coastal zones remaining below 100–200 tons, constrained by short moisture retention and high evaporative demand. The central Peanut Basin shows moderate outcomes between 200 and 1,000 tons, shaped by whether early rains were sufficient for timely planting. The Eastern and upper-Casamance areas again lead, with many cells reaching 1,000–3,000 tons, supported by more stable rainfall sequences and soils that buffered the crop during dry intervals.

Source: Compiled by the authors, based on Africa Agriculture Watch (AAgWa).

Note: Narrative ranges refer to forecast production totals for the mapped spatial unit shown on each map, rather than to yield per hectare.



3.3. Interpreting the Production Patterns for Continental Resilience

Taken together, the production maps reveal not a single national outcome but a differentiated geography of performance. In Senegal, the western littoral areas appear consistently more constrained, the central belt more variable, and the southeastern zones more stable. This reading is valuable for continental resilience because it shows how seasonal shocks interact with pre-existing agroecological conditions, producing uneven outcomes that cannot be understood through national averages alone.

In Senegal, as in other African regions, areas with chronically low production are associated with sandy or shallow soils with low water-holding capacity, making them highly sensitive to short dry spells during reproductive stages. The central corridor's intermediate values reflect its susceptibility to shifts in storm timing rather than seasonal totals, a pattern also observed in the Sudano-Sahelian transition zones of the Sahel belt. The high-performing southeastern departments mirror resilient zones in other parts of Africa, where moderate temperatures, deeper soils, and more reliable rainfall patterns sustain crop development even in years marked by regional deficits.

These structural patterns matter for the Kampala Agenda because they show that climate impacts are heterogeneous and that effective implementation must be grounded in context-specific, subnational action. The role of a continental framework is not to override this diversity but to provide a coordinated GeoAI intelligence service that helps countries detect where seasonal anomalies are reinforcing or weakening baseline vulnerabilities, using comparable methods and interoperable evidence across regions.



4. Building a Continental Resilience Architecture around GeoAI

The patterns revealed by Senegal's 2025 analytics reflect a broader continental logic that a Kampala-aligned resilience system must be built on. The contrasts observed within Senegal—from the structurally low-yield western littoral to the climatically sensitive central belt and the more stable southeastern zone—mirror dynamics that recur across African agro-ecologies. Similar gradients appear in the Sahel, the Horn, and southern Africa when land-surface temperatures, rainfall timing, vegetation dynamics, and AI-based forecasts are analyzed using the same continental systems already developed by AKADEMIYA2063. These shared patterns confirm that African resilience cannot rely on fragmented monitoring tools; it requires a unified geospatial intelligence backbone capable of identifying risks with precision across regions and seasons (AKADEMIYA2063 2024).

A GeoAI-driven continental architecture makes this possible by linking climate anomalies directly to their agronomic consequences. In Senegal, early signals such as cooler northern temperatures, rainfall deficits in the south, and NDVI suppression along the western corridor indicated where production would decline or remain stable. When extended to the continental scale, the same analytical logic enables African institutions to anticipate grain shortfalls, emerging hotspots, and cross-border market pressures months before they materialize. This predictive capacity is central to the Kampala Agenda's aim of shifting Africa from reactive crisis management to anticipatory governance.

A coordinated architecture also strengthens cooperation among Member States, RECs, and AU institutions. Food systems are interconnected, and deficits in one country can affect prices and access across wider regions. Continental anomaly maps and forecast layers can therefore help ECOWAS, IGAD, SADC, and EAC anticipate spillovers earlier. Such a system is also relevant for measuring adaptation. Indicators such as thermal load, canopy vigor, rainfall timing, soil-moisture response, and yield variation can contribute to a common adaptation evidence base, including frameworks such as the GAMA framework (GeoAI-based Adaptation Metrics for African Agriculture), which seeks to track adaptation-relevant conditions and outcomes in a spatially explicit way (AKADEMIYA2063 2026).

Beyond seasonal monitoring, a continental GeoAI architecture supports long-term planning by distinguishing structural vulnerability from seasonal stress. Historical baselines in Senegal, which separate chronically low-performing zones from resilient belts, demonstrate how geospatial intelligence can guide investment targeting for soil restoration, water management, and input delivery. Extending this principle continent-wide enables African governments to design CAADP investment plans grounded in spatial evidence rather than generalized assumptions.

In this sense, **GeoAI is as much an instrument of governance as a technological tool. It enables alignment with national ministries, strengthens statistical and planning systems, and provides continental institutions with a coherent basis for policy coordination.** The Kampala CAADP Agenda seeks to build exactly this kind of continental capability. The Senegal analytics—developed within a broader architecture that already spans multiple African regions—show that the foundations are in place. What remains is the political consolidation and institutional anchoring needed to fully operationalize a continent-wide climate and food system intelligence system.



5. Looking Forward: Consolidating a Continental Shift Toward Predictive Governance

Africa is at an inflection point, where the convergence of climate pressures and digital innovation offers a rare opportunity to redesign how the continent governs its food systems, manages risk, and advances its development ambitions. The analytics developed for Senegal, embedded within a broader continental capability, demonstrate that the tools for this transformation already exist. What is needed now is to consolidate these tools into a coherent African system—one capable of anticipating shocks, coordinating responses across regions, and guiding long-term investments with spatial and scientific precision.

The Kampala CAADP Agenda provides the political framework for this consolidation. By championing a continental approach to climate resilience and digital transformation, the Kampala CAADP Declaration signals a shift away from fragmented national systems toward an integrated architecture rooted in GeoAI and actionable intelligence. This shift will enable Africa to monitor climatic trends across borders, detect anomalies early, and deploy early warning mechanisms to reduce vulnerability in the most exposed agroecological zones. This capacity is essential in a context where a rainfall deficit in one region, a heatwave in another, or a pest outbreak in a third can reverberate across countries through supply chains, price dynamics, and migration patterns (AUC and AUDA-NEPAD 2025a; AUC 2020, 2015).

A forward-looking governance model must therefore embrace this new reality. It must recognize that the future of African resilience will be defined not only by better infrastructure or expanded production but also by the ability to act before shocks escalate. Predictive governance, anchored in geospatial intelligence, enables ministries to intervene earlier in the season, RECs to anticipate cross-border imbalances, and the African Union to guide continental priorities based on continuous, high-resolution evidence. It also strengthens Africa's position in global climate negotiations by grounding adaptation claims in rigorous, spatially explicit data.

Transitioning to such a model requires institutional alignment, strategic investment, and a long-term commitment to harmonizing national data systems with continental standards. It also requires a clear mandate for coordination, ensuring that intelligence generated across Africa informs decisions on agricultural planning, adaptation strategies, emergency responses, and budget allocations. With the Kampala CAADP Agenda as a unifying political horizon, Africa has the opportunity to embed GeoAI at the center of its resilience and development strategy, turning climate and agricultural intelligence into a strategic continental asset (AUC and AUDA-NEPAD 2025b; AKADEMIYA 2063 2024).

As Africa moves forward, the technologies themselves are not the constraint. What matters is the willingness to adopt a new mode of governance—one that treats data not as an afterthought but as the foundation for a more secure, resilient, and self-determined future. Insights from the 2025 season, whether in Senegal or across other regions already monitored through continental platforms, show that Africa is ready for this transition. The question ahead is not whether the continent can build such a system, but how quickly it can mobilize the institutional and political momentum needed to make the Kampala CAADP Agenda a lasting reality.

6. Conclusion

The Kampala CAADP Agenda presents an important opportunity for Africa to strengthen its capacity to manage climate risk, stabilize food systems, and guide agrifood transformation with better evidence. The Senegal analysis shows how geospatial and AI-based tools can reveal the spatial logic of climate impacts, distinguish structural vulnerability from seasonal stress, and translate data into operational foresight. This matters because effective resilience policy depends not only on knowing that a shock exists but also on knowing where it is concentrated, how it is evolving, and which response options are most relevant (AUC and AUDA-NEPAD 2025a; AUC and AUDANEPAD 2025b).

As the continent advances the Kampala Agenda, GeoAI can help align national priorities with regional realities and continental ambitions. Its value lies in improving early warning, supporting adaptation monitoring, informing CAADP implementation, and strengthening coordination across ministries and regional bodies. A coherent continental architecture would be most useful when it supports—not substitutes for—context-specific national and subnational decision-making (Boutayeb, Lahsen-Cherif, and El Khadimi 2025; AKADEMIYA2063 2024).

The analytical capabilities already demonstrated across African settings suggest that this transition is feasible. The next step is political and institutional anchoring: investing in interoperable data systems, analytical standards, and governance arrangements that enable shared continental intelligence to inform local action. If pursued in this way, the Kampala CAADP Agenda can help move Africa toward a more anticipatory, evidence-driven model of resilience governance. Key policy recommendations that emerge include:

- **Invest in national capacity, data-sharing arrangements, and REC-level coordination to ensure that geospatial intelligence translates into timely advisory services, market response, and resilience investments.**
- **Establish a coordinated continental GeoAI service with interoperable standards, while ensuring that analysis and response remain grounded in national and subnational contexts.**
- **Institutionalize subnational risk mapping and seasonal forecast interpretation across CAADP implementation, early warning, and agricultural planning systems.**
- **Develop a shared adaptation metrics framework—building on indicators such as thermal stress, vegetation response, rainfall timing, and production anomalies—to support monitoring, accountability, and climate finance.**

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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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