PARI Thematic Brief No. 2

PARI

October 2025

zef
Center for Development Research
University of Bonn

Innovations for Food and Nutrition Security

Introduction

The agricultural sector remains the mainstay of Africa's economy. The sector employs over 60% of the rural population and supports livelihoods for millions in Africa. Despite its critical role in achieving food and nutrition security, productivity continues to lag significantly behind global standards. For instance, cereal yields in Africa average around 1.6 to 1.7 tonnes per hectare. This is less than half the global average of 4.2 tonnes per hectare attributed to soil nutrient depletion, limited access to inputs, climate variability, and inadequate crop management practices (Ritchie, 2024). Under the 2014 Malabo Declaration, African governments committed to allocating at least 10% of national budgets to agriculture by 2025 to accelerate growth and transformation. However, progress has been uneven, with most countries investing only 3-5% on average. This has, in part, also contributed to stagnant and in some countries declining agricultural value-added growth rates amid global shocks like climate change and market volatility. As the Malabo era concludes, the African Union is transitioning to a new Comprehensive Africa Agriculture Development Programme (CAADP) Strategy and Action Plan for 2026-2035 aiming at boosting agrifood output by 45% through enhanced investments and innovations.

The Program of Accompanying Research for Agricultural Innovation (PARI), implemented across various African countries and India, has explored innovations for food and nutrition security. Drawing on PARI studies, this thematic brief highlights these key innovations, challenges, and lessons to guide future strategies like the CAADP Strategy and Action Plan for 2026-2035 with a focus on the need for scaled investments to close yield gaps, enhance nutrition security, and build resilient agrifood systems.

Insights from PARI on Agricultural Innovations for Food and Nutrition Security

Seeds

The adoption of improved seeds among smallholder farmers in Africa remains low for most crops, underscoring the need for policies and investments to enhance seed systems (Christinck et al., 2018). Despite international initiatives, 70–80% of seeds used in Africa are farm-saved, with maize being a notable exception, showing certified seed adoption rates of about 25% in Southern and Eastern Africa. Seed systems across the continent differ in structure, organization and reach, as illustrated by a comparative study in Kenya and Mali. However, shared challenges persist. The availability of new varieties is limited, particularly in areas affected by climate variability and poor soil fertility. Breeding programs often fail to systematically incorporate important quality and use-related traits. Additionally, slow and costly variety release processes, insufficient

information dissemination about new seeds and cash-flow constraints across various stages of the seed system hinder progress. Addressing these barriers through targeted investments, streamlined regulatory procedures and improved dissemination of seed-related information is essential to foster the adoption of high-quality seeds.

Strengthening seed systems require a comprehensive and integrated approach to improve seed quality, availability and accessibility (Christinck et al., 2018; PARI, 2019). Farmers' demands for specific varietal and quality improvements must be central to seed system development. Long-term funding is essential to sustain the continuous development of new varieties to ensure the durability of seed system initiatives. Innovative institutional arrangements should be pursued to enhance access to improved seeds. These include decentralized certification processes, closer involvement of farmer cooperatives and their networks and stronger collaboration among seed system stakeholders. Improved sharing of varietal information, thorough cost-benefit assessments and greater engagement of rural actors in the seed trade can further support accessibility and adoption.

Decentralized seed services offer a promising strategy to enhance the availability and accessibility of quality seeds for smallholder farmers in Africa (Waithaka et al., 2021). An evaluation of decentralization efforts in Uganda and Tanzania highlights a growing number of stakeholders in the seed sector, including an increase in community seed banks and stronger interactions among them. The production of Quality Declared Seed (QDS) has also expanded, supported by new regulations that address previously unclear areas and introduce fees for inspections, germination and moisture testing, among other processes. Despite these advancements, several challenges persist. In Tanzania, for instance, the management of plant genetic resources remains only partially decentralized and seed testing in both countries still requires further decentralization. Additionally, many community seed banks and QDS farmers struggle with financial sustainability, limiting the full potential of decentralized seed systems.

Fertilizer

There is need for optimal fertilizer application to significantly enhance agricultural yields in Africa which requires strengthening the supply chain, implementing supportive taxation and subsidy policies and improving access to information on fertilizer availability, usage and safety (Olaleye and Edje, 2020; Rezaei and Gaiser, 2018). Africa, soil nutrient depletion - aggravated by insufficient use of external inputs like inorganic fertilizers - has led to widespread soil degradation and declining crop yields. African farmers apply an average of just 22 kg/ha (in 2022), far below the global average of 113 kg/ha (FAO, 2024). Addressing this gap demands comprehensive reforms. Challenges include unfavorable policies, such as high costs from subsidies (e.g. Nigeria), supply chain bottlenecks (e.g. Uganda) and additional tax burdens like the 18% VAT that inflates prices. Issues such as mislabeled or adulterated fertilizers further harm soil health and pose risks to human health when misused. Weak information dissemination and poor coordination among intermediaries exacerbate these problems. Given nitrogen's critical role in plant growth, coordinated policy reforms and private-sector engagement are essential to ensure efficient fertilizer use. Strategic interventions should address affordability, availability and proper usage to promote adequate, sustainable and efficient use of fertilizers.

Yield gaps in Africa could be reduced through the application of organic fertilizer, with even greater impacts when combined with mineral fertilizer. A meta-analysis of 39 studies that investigated the effect of different agroecological practices on land and labour productivity in Africa (e.g. organic fertilizer, crop rotation, intercropping etc.) shows that these practices are associated with a positive and significant difference in land productivity compared to monocrop systems, particularly when monocrops are grown without inputs (Romero Antonio et al., 2024). Among these practices, organic fertilizer most consistently demonstrated yield gains, especially when paired with even small amounts of mineral fertilizer. However, achieving these results would require a significant increase in the amount of organic fertilizer applied which was much higher in the experiments than what is currently feasible in Africa. Such increases would have serious implications for labour and transport demands.

Herbicides

Policies and investments to promote herbicide use need to consider potentially negative impacts on the availability of edible "weeds" which are still widely consumed in Africa. Herbicide use has been associated largely with increasing land productivity and environmental degradation, but not with smallholder farmers' nutrition (Daum et al., 2021). Herbicides are chemicals designed to control or eliminate weeds and promote the growth of crops. However, in cultivating crops there are also edible "weeds", which are a crucial element from the rural food baskets. During the lean season, edible "weeds" contribute to food and nutrition security among households in Zambia. Yet, the increasing use of herbicide is compromising the availability of edible weeds. The decrease of consumption of edible weeds is more evident among those households that have used herbicides for long periods of time. In promoting the use of herbicide, there must be a close monitoring of the trade-offs with food and nutrition security. **Policies and investments aimed at promoting herbicide use must carefully consider the potential negative impacts on the availability of edible "weeds," which remain a vital part of rural diets in Africa** (Daum et al., 2021).

Livestock

Population and GDP growth drives the rising demand for animal-sourced foods in Africa, but the region remains a net importer for meat. Boosting productivity, sustainability, and resilience in the livestock sector requires innovative solutions (Seré, 2020). As trade in animal-sourced foods becomes more formalized and urban consumers increasingly demand higher food safety and quality standards, these trends create opportunities for private-sector investments across diverse value chains. To meet these growing demands, institutional and technical innovations are essential to address the challenges of intensifying livestock production. Key innovations required include improved forages, better fodder conservation techniques, artificial insemination combined with estrus synchronization, intensive beekeeping practices, livestock master plans, livestock asset transfer programs, index-based livestock insurance and enhanced livestock market information systems. **Greater emphasis should be placed on supporting neglected livestock species, which hold significant potential to enhance sustainability while improving nutrition, boosting incomes and empowering women** (Oguche, Kariuki, and Birner, 2021). These species can offer high-quality protein, low fat content and a high dressing percentage, making them valuable for both health and economic benefits. Similarly, smaller livestock like

grasscutters, guinea pigs, guinea fowl and rabbits have less environmental impacts, such as reduced soil compaction and require less land for production. Despite these advantages, widespread adoption of these species is hindered by several challenges. These include issues related to feed and nutrition, susceptibility to diseases and pests, the absence of supportive policies and strategies, limited research and inadequate extension services. Additionally, infrastructural gaps, such as poorly developed markets, further restrict the potential of these livestock species.

Aquaculture

The growth of aquaculture production in Africa remains slow overall, though there are notable exceptions that offer valuable lessons for other countries (Hinrichsen et al., 2022). While aquaculture production has gradually increased across the continent, progress has been uneven, despite the apparent abundance of natural resources and rising demand for blue foods.

To scale aquaculture sectors in Africa, a comprehensive set of policy measures is needed that extends beyond simply increasing productivity to also focus on connecting producers with markets (PARI, 2023; Walakira et al., 2023). A study examining lessons from Egypt, Kenya and Nigeria highlights several barriers to growth in the sector, including inadequate infrastructure, limited development capital, information gaps, insufficient technological expertise and poor governance, among other challenges National policies must aim to enhance productive capacity while also addressing market linkages, supporting high potential regions, increasing local research capacity and effectively scaling research outcomes. Key interventions should include decentralizing seed and feed production to improve access, promoting sustainably farmed fish as a valuable source of animal protein and ensuring that producers are better integrated into value chains. By addressing these structural issues, African aquaculture could achieve more inclusive and sustainable growth.

Farmer Innovations

Traditionally, agricultural innovations have been attributed to research organizations. However, farmers themselves also develop locally adapted innovations that can be rapidly and cost-effectively disseminated (Tambo, 2018; Tambo and Wünscher, 2016). These farmer-driven innovations include technologies and practices applicable across the value chain. They differ from traditional or common methods and are created independently by individual farmers or groups without external assistance. Such innovations arise from modifying existing technologies, inventing new practices, or experimenting with novel ideas. They address agricultural challenges by generating site-appropriate solutions. Importantly, enhancing farmers' innovation capacity could empower them to autonomously adapt to changing conditions. Experiences in Ghana reveal that farmer innovations significantly increase household income and consumption. They also improve food security by boosting household food consumption expenditure, shortening periods of food shortages and reducing hunger severity (Tambo and Wünscher, 2016).

Insights from four PARI-led innovation contests revealed the significant innovative potential of farmers, particularly in pest control and livestock health (Tambo, 2018). In Ethiopia, Kenya, Malawi and Zambia, the contests identified primarily technical innovations, with relatively few institutional innovations. The most common areas of innovation were livestock, crop management and soil and water management. Many farmers utilized local resources to develop plant-based biopesticides and ethnoveterinary

medicines, reducing production costs and enhancing food production. This highlights the rich ethnobotanical knowledge and innovation potential among farmers, which should be harnessed and supported. These experiences show that contests offer an effective platform for identifying and rewarding farmer innovators while also raising awareness of their contributions among stakeholders.

Stimulating the development and adoption of farmer innovations requires greater recognition of their value within formal research systems. support measures must also be directed toward innovators (PARI, 2016). Detailed documentation of successful innovations and their dissemination through local extension systems could further facilitate adoption. Follow-up actions, such as scientific validation, value addition, linking farmers with small- and medium-sized agribusinesses and commercializing promising products, will also be essential for scaling these innovations. Awareness and understanding of intellectual property rights (IPRs) among innovators (Tambo et al., 2020) are also an important source of agricultural innovations.

KEY TAKE AWAYS

Reducing yield gaps: Africa's cereal yields lag behind global averages, but locally tailored innovation packages combining for instance optimized fertilizer use, high-yield cultivars and better farming practices can significantly boost productivity.

Fertilizer challenges: Low fertilizer use in Africa contributes to declining yields. Addressing high costs, supply chain issues and low-quality or fraudulent products requires coordinated policies and private-sector engagement.

Organic fertilizer potential: Organic fertilizer, especially when combined with mineral fertilizer, can boost productivity, but the high levels required could pose labour and transport challenges.

Improving seed systems: Adoption of improved seeds is low, with most seeds being farm-saved. Decentralized seed systems, long-term funding and better dissemination of information can enhance seed availability and use.

Herbicide trade-offs: Herbicides improve yields but reduce edible "weeds" that are critical for nutrition during lean seasons. Policies must balance productivity gains with nutrition security.

Neglected livestock species: Smaller species like grasscutters and guinea fowl offer sustainability and nutrition benefits but face challenges such as disease, limited research and poor market infrastructure.

Scaling aquaculture: Policies must address market linkages, infrastructure and research, with key actions including decentralizing seed and feed production, promoting sustainable fish farming and integrating producers into value chains

Farmer innovations: Farmers independently create locally adapted innovations, addressing challenges like pest control and livestock health, improving food security and incomes while reducing costs.

REFERENCES

Christinck, A., Rattunde, F., Kergna, A.O., Mulinge, W., Weltzien, E., 2018. Identifying Options for the Development of Sustainable Seed Systems – Insights from Kenya and Mali (ZEF Working Paper No. 165). Center for Development Research, University of Bonn, Bonn.

Daum, T., Vehre, A., Schweizerhof, C., Schunko, C., 2021. Edible weeds and food and nutrition security in the face of the herbicide revolution. A case study from Zambia. Int. J. Agric. Sustain. 20, 1166–1180. https://doi.org/10.1080/1 4735903.2022.2065949

FAO, 2024. The State of Food Security and Nutrition in the World 2024: Financing to end hunger, food insecurity and malnutrition in all its forms. UN Food and Agriculture Organization, Rome.

Gupta, A., Shinde, C., Dey, A., Patel, R., Patel, C., Kumar, V., Patel, M., 2019. Honey Bee Network in Africa: Co-creating a Grassroots Innovation Ecosystem in Africa (ZEF Working Paper No. 178). Center for Development Research, University of Bonn, Bonn.

Hinrichsen, E., Walakira, J.K., Langi, S., Ibrahim, N.A., Tarus, V., Badmus, O., Baumüller, H., 2022. Prospects for Aquaculture Development in Africa: A review of past performance to assess future potential (ZEF Working Paper No. 211). Center for Development Research, University of Bonn, Bonn.

Oguche, Kariuki, and Birner, 2021. Is there Unrecognized Potential in Neglected Livestock Species?. Working Paper 11-2021, Universität Hohenheim, Stuttgart.

Olaleye, A.O., Edje, O.T., 2020. Mobilizing Investments in Fertilizer Production and Distribution in Ethiopia, Nigeria and Uganda (FARA Research Report No. 5(15)). Forum for Agricultural Research in Africa, Accra.

PARI, 2016. Farmer Innovation Contests – Tapping the Innovative Potential of Smallholder Farmers (PARI Policy Brief No. 2). Center for Development Research, University of Bonn, Bonn.

PARI, 2019. Seed System Development - Fertile Grounds in Sub-Saharan Africa. Identifying Options for Sustainable Development (PARI Policy Brief No. 15). Center for Development Research, University of Bonn, Bonn.

PARI, 2023. Farming for Fish: Success factors for expanding Africa's aquaculture sector (PARI Policy Brief No. 34). Center Development Research, University of Bonn, Bonn.

Rezaei, E.E., Gaiser, T., 2018. Yield effects of selected agronomic innovation packages in maize cropping systems of six countries in SubSaharan Africa (ZEF-Discussion Papers on Development Policy No. 257). Center for Development Research, University of Bonn, Bonn.

Ritchie, H. 2024. Cereal yields have increased in all regions, but Africa lags behind. Our World in Data. https://ourworldindata.org/data-insights/cereal-yields-have-increased-in-all-regions-but-africa-lags-behind

Romero Antonio, M.E., Faye, A., Betancur-Corredor, B., Baumüller, H., von Braun, J., 2024. Productivity effects of agroecological practices in Africa: insights from a systematic review and meta-analysis. Food Secur. https://doi.org/10.1007/s12571-024-01504-6

Seré, C., 2020. Investing Sustainably in African Livestock Development: Opportunities and Trade-Offs (ZEF Working Paper No. 194). Center for Development Research, University of Bonn, Bonn.

Tambo, J.A., Wünscher, T., 2016. Beyond adoption: welfare effects of farmer innovation behavior in Ghana (ZEF-Discussion Papers on Development Policy No. 216). Center for Development Research, University of Bonn, Bonn.

Tambo, J.A., 2018. Recognizing farmer-generated innovations through contests: insights from four African countries. Food Secur. 10, 1237–1250. https://doi.org/10.1007/s12571-018-0835-y

Tambo, J.A., Baraké, E., Kouevi, A., Munthali, G.T., 2020. Copyright or copyleft: An assessment of farmerinnovators' attitudes towards intellectual property rights. J. Rural Stud. 74, 133–141. https://doi.org/10.1016/j. jrurstud.2020.01.004

Waithaka, M., Mugoya, M., Mabaya, E., Tihanyi, K., 2021. Decentralized Seed Services in Africa: An Assessment of Tanzania and Uganda (ZEF Working Paper No. 206). Center for Development Research, University of Bonn, Bonn.

Walakira, J.K., Hinrichsen, E., Tarus, V., Langi, S., Ahmad, N., Badmus, O., Aziz, A., Baumüller, H., 2023. Scaling aquaculture for food security and employment in Africa: Insights from Egypt, Kenya and Nigeria (Working Paper No. 223). Center for Development Research (ZEF), Bonn, Germany.

All studies are available at www.r4ai.org.

PARI implementing partners: ZEF/University of Bonn, University of Hohenheim, the Forum for Agricultural Research in Africa FARA) and its national partners, the African Growth and Development Policy Modeling Consortium (AGRODEP) facilitated by AKADEMIYA2063, and research collaborators in India.

PARI is funded by the German Federal Ministry for Economic Cooperation and Development (BMZ).

Brief prepared by: Heike Baumüller, Friederike Schilling, Emmanuel Tolani, and Joachim von Braun

Layout: Yesim Pacal (PR)

IMPRINT

Center for Development Research (ZEF)

Genscherallee 3 | 53113 Bonn | Germany

E-Mail: presse.zef@uni-bonn.de

Phone: +49-(0)228 - 73 18 46

zef
Center for
Development Research
University of Bonn