INITIATIVE ON Mixed Farming Systems

CGIAR

Info Brief

Diverse stakeholders share practice, knowledge and expertise at the MFS annual field day. (E.Mwale)

Sustainable intensification of smallholders' maize-based mixed farming systems in Malawi

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IITA Transforming African Agriculture

Malawi Government
Min. of Agriculture & Irrigation

Info-brief: Sustainable intensification of smallholders' maize-based mixed farming systems in Malawi

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The Sustainable Intensification of Mixed Farming Systems Initiative aims to provide equitable, transformative pathways for improved livelihoods of actors in mixed farming systems through sustainable intensification within target agroecologies and socio-economic settings.

Through action research and development partnerships, the Initiative will improve smallholder farmers' resilience to weather-induced shocks, provide a more stable income and significant benefits in welfare, and enhance social justice and inclusion for 13 million people by 2030.

Activities will be implemented in six focus countries globally representing diverse mixed farming systems as follows: Ghana (cereal–root crop mixed), Ethiopia (highland mixed), Malawi: (maize mixed), Bangladesh (rice mixed), Nepal (highland mixed), and Lao People's Democratic Republic (upland intensive mixed/ highland extensive mixed).

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Key messages

Agronomic solutions for improved maize-legume intercropping systems, such as Mbili Mbili and Double Row Strip Cropping, integration of maize-legume rotations, combined with soil health and multi-purpose forages innovations for enhancing crop-livestock integration, have been validated as transformative for sustainable intensification.

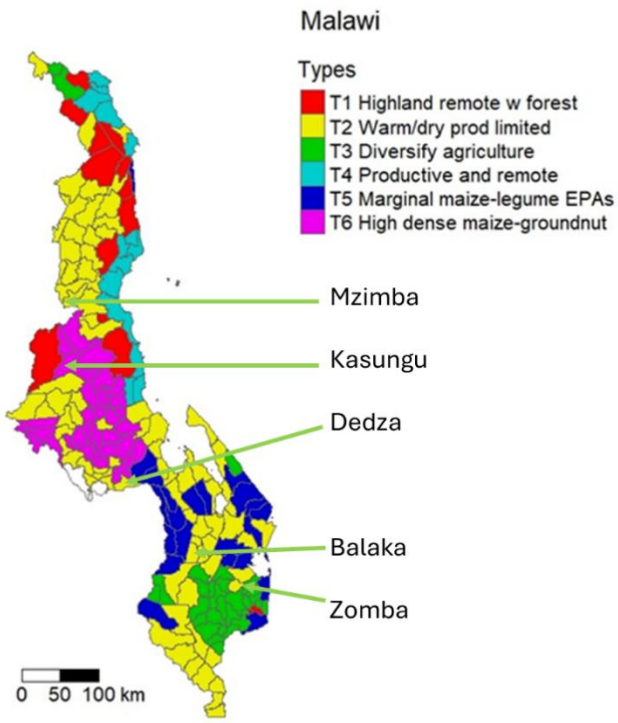
These systems support farmers—especially women and youth—to diversify and intensify farming activities, sustainably raising production on small plots, enhancing soil health, and ensuring profitability. By promoting legumes, often considered women's crops, these innovations contribute to more inclusive decision-making and diversified diets.

To enable uptake, farmers must have access to cash income to afford the inputs, including legume and forage seeds, organic and inorganic fertilizers, and the capacity to tailor agronomic advisories. Researchers engaging scaling partners through local-level platforms is one way to combine technical with socio-organizational innovations.

The context

Malawi's agricultural landscape has long centered on maize monoculture systems. However, these systems have increasingly come under pressure due to challenges from limited land availability, soil degradation, climate-related impacts, and restricted access to input and output markets (Mwale et al., 2022; Chimonyo et al., 2023). Smallholders, who form the majority of farmers, often lack income alternatives, experience low dietary diversity, and face socio-economic challenges like dependence on external support, weak local leadership, and gender disparities affecting agricultural practices and resource access (Snyder and Sulle, 2022; Tufa et al., 2023).

The CGIAR Mixed Farming Systems (MFS) initiative aims to address the multiple challenges that Malawian smallholder farmers face. Through maize-legume integration, organic and inorganic fertilizer combinations, inoculation, crop rotation, conservation agriculture, the introduction of improved crops and forages, the initiative explores field-tested technologies, tailored to farmers' needs, to improve yields, restore soil health, and strengthen resilience. With participatory, gender-responsive technology selection, supported by experiential learning and capacity development, including field days, MFS builds engagement with farmers and implementing partners.



Farming systems and study sites in Malawi (Cossu et al., 2024)

Malawi's MFS team has established partnerships and capacity-building initiatives with the national research and extension systems and diverse stakeholders, to co-design and adapt innovations for different agroecological zones. These collaborations are laying the foundation for sustainable scaling, supporting improved food security, income stability, ecosystem health and climate resilience across the agricultural sector.

Approaches to MFS: adaptive, multi-stakeholder, and cross-scale

The MFS initiative in Malawi adopts an integrated, adaptive systems research approach, focusing on diversifying maize-based cropping systems and enhancing crop-livestock integration. This approach aims to enhance the overall benefits of the system, recognizing that the combined impact of diversified components is greater than the sum of their individual contributions. Research is conducted through iterative cycles, continually evaluating and adapting technical innovations based on co-creation principles. The DEED (Describe, Explain, Explore, Design) framework was adapted by the research team in Malawi, with on-farm research at its core, in practice taking local knowledge into account, and joint effort in co-designing the technical innovations for system improvements (Gebreyes et al., 2023). Partnerships and multi-stakeholder feedback across various scales are central in facilitating learning and setting the stage for scaling innovations.

Describe: A farming systems typology was developed based on secondary data and contextual analysis to ensure that technical innovations are contextually relevant. This typology stratifies Malawi's diverse farming systems and household types based on similar characteristics, enabling more precise targeting and tailoring of interventions. Baseline and capacity needs assessments and stakeholder engagement, including understanding capacity needs for stakeholders, help characterize these systems and identify challenges, ensuring that the technical innovations are better suited to specific needs, making it more likely they will be adopted (IITA, 2023). This also provides a foundation for developing adoption and impact scenarios for validated innovations.

Explain: Participatory evaluation, community level, and multi-stakeholder assessments form the backbone for explaining the challenges with regards to crop and livestock value chains and institutional bottlenecks. On-farm and on-stations trials are implemented to test and validate soil health, intercropping systems, and crop livestock innovations. Farmers' preferences, perceptions, and priorities are assessed to tailor innovations to the specific needs of different farming contexts. This also ensures that innovations are gender-responsive, addressing the distinct challenges faced by female, youth, and male farmers across various resource levels. Fostering a shared understanding ensures that solutions are practical and beneficial for the entire farming system.

Explore: System evaluations applying the SIAF framework, conjoint and other choice experiments, and impact assessments further explore and generate research

evidence for these innovations. Embedding reflections in existing multi-stakeholder platforms, held each year during and at the end of the growing season at the community level and through the District Agricultural Extension Coordination Committee (DAECC), helps to refine the innovations and identify partnerships that address bottlenecks for scaling. Research, thereby, creates conditions for continuity beyond the initiatives' timelines.

Design: Prototyping improved farming systems configurations and identifying mechanisms for addressing key bottlenecks helps developing scaling strategies, with appropriate institutional support. The insights help build partnerships, address capacity needs, and highlight policy implications that support wider adoption. In doing so, the approach fosters incremental improvements and lays the groundwork for more transformative changes in Malawi's farming systems.

Farming systems diagram, illustrating important concepts and interlinkages from the perspective of MFS scientists with regards to maize-based farming systems in Southern Malawi (E.Mwale)

Key results and opportunities

Technical innovations

Cereal-legume integration

Several intercropping approaches with different spatial configurations and cereal legume rotation were tested, engaging at least 40% women and 10% youth farmers. The aim was to enhance the benefits of legumes without compromising maize yields, addressing constraints related to land availability, soil fertility, and low legume productivity, and contributing to food security, income diversification, and climate resilience. Intercropping increased yields, provided more diversified grains and biomass, and encouraged joint decision-making in households, helping balance labor and share productivity gains more equitably. However, labor peaks during food shortages and high seed and fertilizer costs were key bottlenecks. Integrating these intercropping innovations with agribusiness, social protection, and financial support could help smallholders realize productivity, nutrition, and income gains.

Maize legume intercropping, an important SI-innovation to harvest more per unit land, while also aiming to empower women and improve the environment. (E.Mwale)

The **"Mbili-Mbili" intercropping system**, which alternates two rows of maize with two rows of legumes (e.g., beans, soy, groundnuts, and pigeon pea), was adapted from Tanzania's Africa RISING project (Liben et al., 2023). This configuration modifies standard maize spacing (75 cm x 25 cm) to 60 cm x 25 cm to intercrop two legume species while maintaining maize populations, with zinc-biofortified beans added for

enhanced nutrition. Agronomic biofortification of Zn in maize and legumes was integrated as a component to enhance the nutritional productivity of the system. Results showed that Mbili-Mbili increased maize equivalent yields by 11% over conventional maize-bean intercropping, 14% over sole maize, and 135% over doubled-up legume systems (DUL). Farmers preferred Mbili-Mbili for its positive impacts on food security, yield, environmental sustainability, and nutritional diversity.

In **maize-cowpea and maize-soybean intercropping integrated with soil fertility management** (ISFM), row spacing was reduced to improve productivity, from the national recommendation of 75 cm to 50 cm, and within row spacing for maize at 25 cm and for cowpea at 20 cm, with two maize rows alternating with two rows of either cowpea or soybean. Trials showed a 91% maize yield increase and 31% cowpea yield increase when manure and rhizobia inoculants were used. Palatability tests showed cows preferred straw feed from the maize-cowpea system, compared to maize only, underscoring the system's value for livestock feed.

Conservation Agriculture (CA) maize-legume intercropping systems with cowpea and lablab and maize-legume rotation systems with cowpea, lablab, pigeon pea and soybean were implemented with and without inoculation treatments. Intercropping arrangements alternated two rows of maize with two rows of either legume, with maize rows spaced at 50 cm. The distance between maize and legume rows was 45 cm, while cowpea rows were spaced 20 cm apart. Maize yields under strip cropping with lablab increased by between 35 and 60% from a baseline of conventional practice. Farmers expressed strong preference especially for soil moisture retention and crop diversity, with extensive ground cover provided by cowpea and lablab. Farmers appreciated CA's resilience benefits, which proved essential during the dry 2023-2024 season and were excited to benefit from additional high nutritional value grain legume crops.

Double-Up legumes and cereal legume rotation were implemented in Dedza's Kandeu, Lobi, Linthipe and Golomoti EPA's in the Central Region of Malawi. Fertilizers used in the trials were enriched with Zinc. Trials were set up with maize, soybean, groundnut and pigeon pea in rotation and double up arrangements. Some long-term sites have been running for more than ten years, showing the soil health build up benefits of double up legumes and integrated soil fertility management. Maize yields were higher in double up legume systems than in the sole cereal-legume intercrop.

Improved spatial configurations of maize legume intercropping as important agronomic innovation. (M.Kinyua)

Data hub for tailored agro-advisory

The agronomy and soil database has been established to facilitate FAIR data sharing and support the provision of tailored agronomic solutions that enhance productivity, income, and soil health in Malawi. This comprehensive database integrates harmonized datasets from government agencies, private organizations, and individual contributors. Multi-institutional partnerships were initiated through consultative meetings to promote data sharing among various entities. Data collection, curation, and cataloguing of 19,234 records on crop responses to fertilizers and 4,743 records on soil conditions have been completed. The development of a web data hub is in progress for data storage and sharing, governed by DARS. This initiative will help create a web-based database within Malawi's national research system, streamlining data management and enhancing the development of customized agronomic advisory services.

Multi-purpose crops and forages

Trials on **dual-purpose groundnut and maize varieties** were conducted to alleviate dry season feed deficits, without compromising grain output. Groundnut varieties included Kakoma, Chitala, CG13, CG14, and Chalimbana 2005 (used as a control), while maize varieties evaluated were Peacock 10, MH30, SC537, DK777, and the

control DK-8053. Trials covered 32 plots (16 for groundnut and 16 for maize varieties). Farmer assessments across all trial sites highlighted CG13 and Chalimbana 2005 as the best-performing groundnut varieties in biomass production and disease resistance, although these varieties produced slightly lower grain yields than others. For maize, yield results varied by site; Peacock 10 and DK777 showed the most consistent high yields.

In Kasungu and Zomba Districts, **soil water conservation** trials introduced dual-purpose grasses (Dwarf Napier, Guatemala, Brachiaria mulato II, and vetiver) along contour ridges to conserve soil and water while providing livestock feed. In 2023/2024, Dwarf Napier and Guatemala grasses demonstrated strong establishment, aligning with farmer and researcher evaluations.

New pasture introductions were evaluated, Brachiaria hybrids (Mulato II, Cayman, Cobra, and Camello), Crotalaria, and a control of Panicum maximum, comparing biomass and growth performance for pasture enhancement across five sites. These included two demonstration locations in Kasungu and Mzimba districts, and three on-station trials at Mbawa, Chitala, and Lunyangwa research stations. Among the Brachiaria varieties, Mulato II demonstrated the highest rate of leaf emergence, showing promising establishment and regrowth potential; its overall biomass yield was however lower than others.

In Mzimba, participatory farm modeling using FarmDESIGN evaluated **contour farming with perennial forages** (Höft, 2024). Farmers revealed soil degradation, dry-season feed scarcity, and erosion as main challenges. While they were familiar with native species, improved forages and their nutritional benefits were less understood. Redesign options integrating forages increased farm income (16-68%) and soil fertility (82-185%) while revealing labor and resource allocation trade-offs. Overall, farmers favored forage allocation to crop systems for enhanced soil fertility.

Feedback from the **national forages seminar** also emphasized raising awareness and promoting on-farm trials with native and cultivated forages to meet livestock nutritional needs. However, lack of seed systems and weak and unstructured livestock markets and value chains remain key obstacles to realizing the full potential of multipurpose forages.

Farmer awareness creation for multipurpose forages, for improved feed, soil health and source of income. (E.Mwale)

Socio-technical integration

The initiative in Malawi, focused on co-designing technical innovations, adopted various participatory approaches to foster joint learning and tailor solutions to farmers' needs. Engaging with farmers and facilitating multi-stakeholder reflections provided valuable insights for packaging sustainable intensification (SI) innovations and forming scaling partnerships.

Farmers—including women, youth, and those with varying resource levels—were consulted on the perceived advantages and disadvantages of conventional practices versus improved SI innovations (Homann-Kee Tui et al., 2024). Key challenges, such as the high costs of fertilizer and seeds, along with increased labor demands during peak seasons (often coinciding with food shortages), were identified. The need for labor saving technologies was highlighted. Women and youth emphasized the limitations of small farm sizes and constrained resources. These insights revealed the importance of addressing economic and labor challenges to unlock the full benefits of SI innovations, which have already demonstrated positive impacts on food security, nutrition, and the environment through on-farm trials. For example, limited access to credit and underdeveloped markets hinder farmers' ability to invest in improved inputs, while the knowledge-intensive nature of intercropping, including planting, spacing, and weeding, necessitates external support for effective adoption.

Annual reflections, encouraging women and youth participation at community meetings and through the District Agricultural Extension Coordination Committee (DAECC), helped refine participatory agronomic trials, including comparisons of diverse legumes with conventional intercropping. Scaling partners—NGOs, government bodies, and private organizations—were identified at the local level to expand learning across different farm types and integrate SI innovations with complementary practices, such as crop-livestock integration, nutrition sensitization, and soil and water conservation programs. A national scaling readiness workshop identified key bottlenecks, such as limited access to inputs, labor challenges, and insufficient technical capacity, which scaling partners can help address. These stakeholder reflections at both local and national levels have provided actionable insights and should continue to shape future efforts. Integrating activities in existing platforms enhances learning and supports continuity in program transitions.

Conclusions and recommendations

Addressing multiple outcomes: The initiative's activities highlight the need for innovations that address economic and labor challenges, enhancing the established benefits from technical innovations, in terms of food and nutritional security, as well as environmental and social gains. These innovations, validated along with on-farm testing of sustainable intensification (SI) practices, offer potential entry points to expand these benefits for broader farmer adoption.

Co-creating socio-technical innovations: Inclusive processes that prioritize farmer needs, multi-stakeholder capacities, and collaborative interests are essential to overcoming the technical and socio-organizational bottlenecks to innovation adoption. This approach can increase the relevance and utility of solutions across diverse farm typologies, leading to improved rural livelihoods. To tackle challenges such as limited cash flow for inputs, solutions must extend beyond agronomic practices to align with stakeholders' shared interests, capacities, and policy frameworks.

Leveraging multi-stakeholder platforms: Malawi's multi-scale District Agricultural Extension Services System (DAESS) offers a valuable platform for researchers and partners to co-design, test, and evaluate technical innovations collaboratively. Engaging these platforms in co-learning and shared analysis can foster socio-organizational support structures that facilitate the uptake of technical innovations. Understanding the functionality of these platforms and creating spaces for reflection and learning are critical to the sustainable scaling of socio-technical solutions.

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The CGIAR Research Initiative on Mixed Farming Systems aims to provide equitable, transformative pathways for improved livelihoods of actors in mixed farming systems through sustainable intensification within target agroecologies and socioeconomic settings.

It forms part of CGIAR's new Research Portfolio, delivering science and innovation to transform food, land, and water systems in a climate crisis.