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Zentrum für Entwicklungsforschung
Universität Bonn

ZEF POLICY BRIEF NO. 61

DIVERSIFICATION OPPORTUNITIES IN AGRICULTURE

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December 2025

INTRODUCTION

Across the globe, but in particular in high-income countries, we find high yielding agricultural systems characterized by monocultures with high inputs of chemicals and pesticides [1] with significant social and ecological impacts. At the same time, we find highly diversified, often smallholder farming systems, in particular in Sub-Saharan Africa [2], where they provide 80% of the food consumed in Africa[3]. Which agricultural farming practices are established is shaped by ecological and economic conditions but also other factors that are often overlooked including policies and available knowledge from science[4].

But science is not necessarily reflecting the needs and priorities in low-income countries, and in particular not of marginalized groups. Research in land use produced to inform practices and policies is disproportionately shaped by white and male scholars/researchers [5,6], which can often lead to biased narratives and research whose design does not necessarily reflect the global diversity of farmers and contexts. Between 2000 and 2021, women only made up 27% of authors in the field of land science globally, and among them Black and Hispanic women were the least represented at 2% and 6% [7], respectively. This lack of diversity constrains perspectives, limits innovation, and risks overgeneralizing solutions. While many factors including finances, local context, and policies influence and shape science, researchers' background including gender, age, sexual orientation, class, religion, race, and the intersection of the traits, contribute significantly to the questions asked and potential solutions proposed by science.

Policy processes reinforce these challenges of simplification. Many evaluations mechanisms exclude key stakeholders, lowering legitimacy and increasing the likelihood of failure[8]. Rather than linear impacts, policies have a myriad of impacts, many unintended. Evaluation processes that do not consider diverse actors and local contexts risk missing systemic interactions and not accounting for unintended impacts on different actors. A bias in considered interests risks that policies and measures are not accepted by other actors relevant for the implementation thereby risking total project failure.

Simplification of complex systems in the context of science and policy is likely to promote simplified agricultural farming practices with serious consequences on resilience of agricultural systems, livelihoods, dietary options, and biodiversity.

Smallholder farmers: The inadvertent recipients of simplification

Smallholder farmers, who make up much of the agricultural workforce especially in Sub-Saharan Africa, are particularly negatively affected by simplification. National policies often favor large-scale monocultures through subsidies or by domesticating global programs such as FAO's "one country, one product" across Africa. For example, in Gabon, the priority crop grown is maize[9]. Market incentives combined with volume discounts on input supplies are often tailored to specific crops thereby reinforcing farmers dependence on monocultures [10]. An intersectional perspective in land use science highlights how factors such as gender, class, ethnicity, access to credit, and tenure security mediate farmers' ability to engage with or resist monoculture systems. Yet, intersectional factors—such as gender, class, and land tenure—shape who can and will pursue diversification strategies and who remains locked into monoculture, underscoring the need for more equitable approaches in land use science. Research in the land use field is still conducted predominantly by men, which shapes the kind of innovations and solutions that are prioritized. As a result, many interventions are better suited to men´s roles and experiences, even though about 40% of the

labor force in agriculture are women. The result is a cycle of system-level simplification across science, policy, and practice that reduces resilience and entrenches inequalities.

How diversification can address these challenges

The concept of diversification is not new on farms. In agriculture, diversification is predominantly understood as moving beyond reliance on a single crop by using multiple species across time and space, thereby reducing the risks tied to depending on just one. Agricultural diversification is, therefore usually understood in the frame of farming practices and includes the use of cover crops, mixed cropping, complex rotations, agroforestry, embedding natural habitats such as vegetation strips, and use of boundary plants such as hedgerows.

In farming, crop diversification helps mitigate multiple risks. For example, integrating nutrient fixing crops can lower fertilizer needs, while hedgerows that repel pests reduce reliance on pesticides – an important input risk among smallholder farmers. Diversification also reduces yield risks: combining different crops with different functional traits, such as in agroforestry systems, enhances resilience to pests and climate change. Planting crops with staggered maturity periods can reduce labor and market risks by spreading out harvests and providing farmers with produce over the year. Crop and farming practices that improve soil fertility, such as crop rotations and use of cover crops, promotes microbial interactions and soil`s water holding capacity, and help mitigate soil degradation risks. In turn this supports ecosystem functioning and services.

In science, diversification can take the approach of epistemological pluralism of methods and research teams. Diverse teams with diverse perspectives have the potential to enhance innovation, ensure solutions are inclusive, and avoid prescriptive outcomes. Diversity of researchers with diverse backgrounds can broaden the scope in science and innovations. In policy, diversification requires inclusive and participatory decision-making and evaluation. Bringing in all stakeholders to include all groups of people who would be affected, who can affect, and those that have interests [11] enables co-development of solutions and innovations that best reflect and address the challenges of the communities and enhance policy legitimacy.

Recommendations to encourage and utilize the benefits of diversification

- **Transforming agriculture today will require system level interventions.** Interventions must go beyond farm-level practices to target the root causes (drivers) of simplification (policies and science) and their pressures (lack of diversity).
- Agriculture will face increasing demands to provide provisioning, regulating, and cultural ecosystem services in the context of future climate change. **Policy development should leverage pluralism of stakeholders and all their viewpoints.** Stakeholder diversity can be a source for co-development of solutions that are both scalable and flexible.
- **Science spaces need to increase diversity in gender and ethnicity among research teams.** This can be achieved by promoting equitable hiring practices and increasing the representation of women and other underrepresented groups in senior positions, providing financial and organizational support for researchers during parental leave, and expanding mentoring programs for early-career female researchers. Diverse viewpoints and perceptive are crucial in agriculture for understanding complex challenges and developing solutions and innovations that are inclusive, rather than limited to the perspectives of homogenous groups. Importantly, diverse teams also drive the advancement of scientific knowledge.

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This work was funded by the Bundesministerium für Forschung,Technologie unf Raumfahrt (BMFTR) under the *At the Science Policy Interface: LANd Use SYNergies and CONflicts within the framework of the 2030 Agenda* (LANUSYNCON) project, grant number 01UU2002.

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Layout: Yesim Pacal and Ricarda Mundt / ZEF PR

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