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# Agricultural research approaches for crops that nourish by improving nutrition, soil health, resilience and prosperity

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Addressing nutrition and climate resilience together requires transdisciplinary participatory action research with clear impact pathways for systems change that starts from the ground up. The concept of 'crops that nourish' is proposed here to offer a new mode of pursuing agricultural development. It involves iterative co-creation between farmers and researchers that prioritizes local needs and agency, human health, resilience and sustainability through a focus on opportunity crops.

Agricultural systems in sub-Saharan Africa stand on the precipice of transformation. In an era of instability in global systems and markets, the continent is burgeoning with a young, increasingly educated population and tremendous energy to accelerate food systems change for greater prosperity and resilience. Yet biophysical (for example, land degradation), socioeconomic (for example, food insecurity) and (geo) political (for example, conflict) challenges persist. These challenges are highly interrelated, presenting a great opportunity for systems change by working at key leverage points. We argue that focusing agricultural research on the concept of 'crops that nourish' presents one such transformative leverage point.

'Crops that nourish' describes crops and cropping systems with characteristics that improve soil health, are resilient to environmental stressors, are highly nutritious, are produced through participatory processes that empower farmers and their communities, and have unrealized private and public benefits[1]. To illustrate how it can be a systemic leverage point, consider that dietary diversity is a key element of healthy diets and diverse value chains are resilient to economic and environmental shocks[2], while agrobiodiversity facilitates access to diverse foods, helps maintain soil health and sustains genetic diversity and ecosystem services more broadly[3,4]. Rural communities have long nurtured agrobiodiversity in local systems. Their expertise and partnership are fundamental to identifying context-specific opportunities for crop and value chain improvement.

New ways of conducting agricultural research are needed to support broad goals of food system transformation, starting from local priorities. Such a paradigm takes an expansive view beyond narrow concerns for food security (calories) and crop productivity (yield) to incorporate nutrition, soil health, resilience, climate change, improved market access and local prosperity for farming communities. Crops historically ignored by agricultural research (for example, neglected or underutilized) can be revalorized as opportunity crops[5]. Take amaranth, for example, a pseudo-grain rich in protein, fibre, iron and phytochemicals, generally resilient to wide variations in climatic conditions, that can convert insoluble soil phosphorous to forms available for plant uptake, benefitting neighbouring and subsequent plants[6]. Opportunity crops provide significant public benefits by addressing environmental and nutrition challenges, and largely unexplored private benefits. Research can fill the large evidence gap, but doing so requires approaches that evaluate success on factors beyond yield alone with clear impact pathways driven by producer and consumer priorities[5].

Conventional agricultural research achieved great staple grain yield gains and stable producer prices, especially across Asia, but also generated unintended consequences for environmental sustainability and nutrition. Focus on rice, wheat and maize missed most African staple foods. Contemporary challenges and increased understanding of nutrition demand agricultural research to take a broader perspective and design for holistic agrifood system outcomes[7]. Scaling crop diversity through opportunity crops is a powerful strategy to build healthier and more resilient food systems. Here, we argue there are at least three important dimensions to research aligned with the 'crops that nourish' concept that support the goals of food systems transformations: transdisciplinary collaborations focused on problems defined by local stakeholders in communities; participatory action research (PAR); and a focus on clear impact pathways that support capacity building and agency with evidence-based links to wider food systems change.

## Transdisciplinary collaborations

Current research often operates in disciplinary silos pursuing scientists' priorities. Addressing the confluence of development and environmental challenges requires going beyond multidisciplinary science to engage farmers and communities in co-producing solutions that respond to their realities, objectives and opportunities. Such transdisciplinary collaborations include a broad range of scientists (social and natural) together with food system actors in communities in a problem-driven and solutions-oriented partnership[8]. The need for transdisciplinarity is especially acute in plant breeding because it often requires choosing between different traits. For example, choosing tannin levels in Bambara groundnut. High tannins make the groundnuts harder to cook and digest but also are higher in antioxidants and have better storage and pest resistance[9]. Participatory breeding aims to find the optimal balance. Collaboration between community members and plant scientists — with careful attention to issues of power, detailed below — is necessary to make choices that are embedded in cropping systems and reflect farmers' needs and goals. Participatory plant breeding programmes facilitate this co-creation as an alternative to scientist-led approaches[10]. Breeding is one step in the process; 'crops that nourish' calls for participatory approaches throughout product and value chain development. Dialogue and debate allow diverse perspectives on choices and tradeoffs to be reflected in final products and actions taken. Listening to farmers, communities and other actors throughout agricultural value chains and civil society is necessary to set the priorities that most matter for people's lives and livelihoods.

Although engaging in transdisciplinary collaboration increases the chances of empowering local actors, it is important to be mindful of power asymmetries. Such power dynamics have resulted in the benefits of well-intentioned development programmes being captured by better-off members of communities or the international private sector. Recognizing and respectfully engaging multiple perspectives and forms of knowledge, expertise, resources and values with an awareness of social positions can work to address structural and systemic problems[8]. Further, working in this way is more likely to yield insights that are seen as legitimate due to their inclusive processes[11] and, when combined with strong policy and institutional engagement, are well-positioned to translate science more effectively into impact[7].

Critically, realizing the transformative potential of opportunity crops demands dedicated investments in developing scientific talent across disciplines within Africa. Building scientific excellence, including strengthening African agricultural research centres and universities, is essential to sustainably address local challenges, seize opportunities and ensure long-term success and ownership of agrifood innovations by African scientists. Relevant to all areas of agricultural research, we argue several domains are particularly important for opportunity crops and have been historically underrepresented, warranting additional investment. These include gender-sensitive approaches, systems science, nutrition education, behaviour change communication and market intelligence.

Finally, opportunity crops are embedded in local cultures and communities, having many food and non-food uses and values. People are rooted in cultures, traditions and societies, and participate in broader agricultural and market systems beyond any single crop, so a holistic perspective of agrifood systems reflects the reality of people's lives. When communities lead innovation creation, solutions relevant to the systems within which they operate emerge.

The concept of 'crops that nourish' describes transdisciplinary innovation processes with three features (Fig. 1): (1) addressing local concerns defined through participatory processes; (2) incorporating nutrition, agronomic and socioeconomic considerations jointly, and addressing tradeoffs across these goals through dialogue, participation in decision-making and iterative implementation; and (3) engaging in research that meets combined needs, jointly setting goals within systems rather than by crop.

## Participatory action research

Addressing local needs calls for PAR throughout product and value chain development; from breeding, seed systems strengthening and agronomic practices to demand creation and market development. PAR relies on co-learning by community members and scientists to develop innovations that neither could develop alone[12]. Co-creation creates collaborative advantages by joining farmers' deep crop and context knowledge with researchers' scientific knowledge and techniques. In participatory breeding, farmers are actively involved in varietal selection, ensuring breeding results in demand-driven target products and supports farmer adaptation to local conditions. Furthermore, linking participatory breeding with empowering farmers and farmer organizations in seed management and within seed systems helps to ensure that newly developed varieties reach farmers and enhance varietal diversity[13]. Finally, breeding efforts must ensure that inherent traits conferring climate resilience are not foregone in the improvement process, and that new vulnerabilities are not introduced.

Participatory on-farm experimentation for breeding and agronomic research is well-positioned to achieve these objectives by centring farmers' perspectives and actions in product and practice development. Snapp et al. demonstrate how using PAR with farming communities in Malawi revealed that pigeon pea was valued for features beyond its commercial value including food, soil fertility, fuel and forage. The researchers' prior focus on early maturity varieties for food insecurity overlooked food and grain storage qualities that farmers required[12]. A frequent concern about on-farm trials is the diversity and heterogeneity of farmers' environmental conditions and objectives. Yet we can now integrate evidence from examples working with farmers across ecologies and scales[13] and have new tools to manage this complexity; modern data collection, sensor systems and analytics can address high variability on-farm and generate reliable generalizable results.

There are many stakeholders to consider. Participatory research goals should be collaboratively driven by farmers, food processors, cooks and/or food preparers and consumers to develop and bring regionally grown agricultural products to market. Power structures may limit who participates, reducing ultimate impacts. For instance, women's contributions to research activities and decision-making can help ensure that their concerns about cooking qualities and labour demands, historically often overlooked, are considered. Inclusive and equitable implementation would focus on marginalized farmers and community members and prioritize opportunities for their empowerment.

## Impact pathways

Impact pathways articulate the logic behind a theory of change, connecting actions to outcomes through specific intermediate steps and providing a broad view of the process of change[14]. A 'crops that nourish' approach includes continuous priority setting, adaptive management and feedback, and knowledge management to drive research, development, improvement and ultimately implementation along the value chain[12]. We argue the key elements for success include co-locating

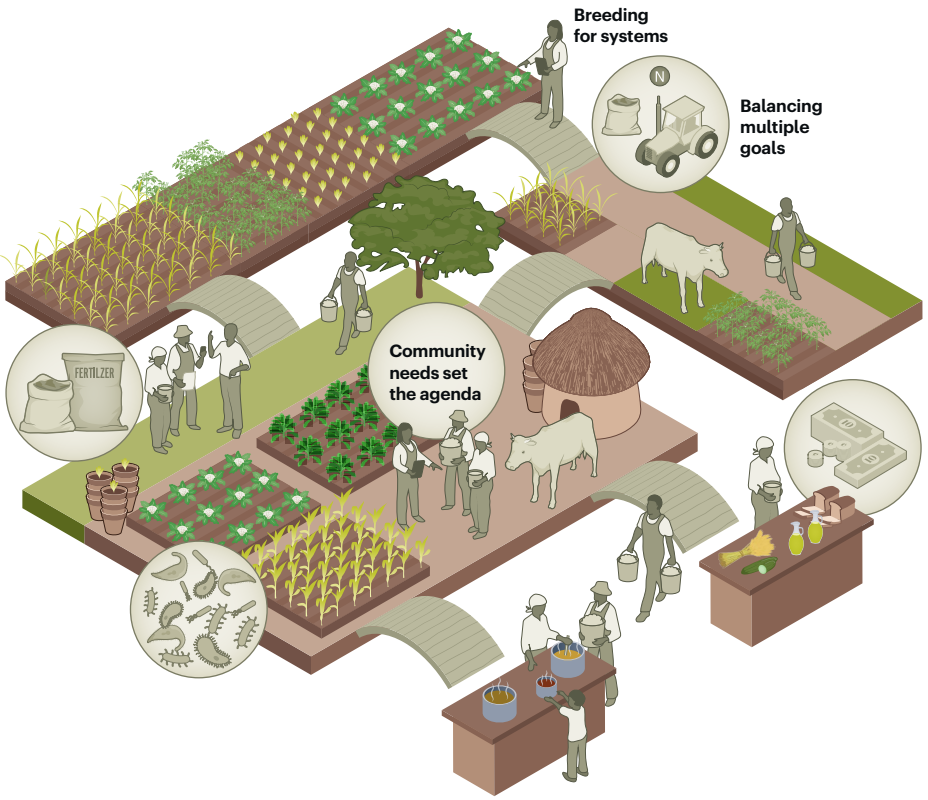


**Fig. 1 | Transdisciplinary collaboration across the value chain for diverse, resilient and nourishing crops and foods.** Realizing community needs through transdisciplinary and participatory collaborations that engage all stakeholders and are embedded within existing systems throughout the product development pipeline.

research activities (for example, breeding and seed systems development) in specific contexts while sharing resources and responsibilities to amplify what any one group of farmers could achieve on their own. Champions can play a central role in this process and through capacity development, policy advocacy and market development[15].

Policy action is required to ensure that farmers retain value when systems inevitably change[1]. For instance, policies are needed to incentivize local consumption (for example, home-grown school meals), strengthen open and community-led seed systems, and strengthen farmers' access to and bargaining power in market transactions such as through supporting producer marketing groups and cooperatives. Seed system strengthening that preserves community agency is an integral part of opportunity crop improvement and should be a priority going forward and emphasize local entrepreneurship and job creation, expanding seed availability and improving quality. Agro-processing for opportunity crops also presents opportunities for large- and small-scale entrepreneurship and innovation. Lastly, access to markets often requires expanding demand through approaches such as marketing and education campaigns, targeted subsidies, infrastructure investment and access to financial services (for example, insurance).

African markets and opportunity crops have unique characteristics that will shape which policy tools are most effective to achieve inclusive impact at scale. For the crops, these include, for example, perishability, multiple uses and intermediate growth patterns between annual crops and perennial trees. For markets it is factors such as the level of product diversity, types of vendors, formalization, degree of intermediation and integration with other markets. Earlier literature on neglected and underutilized species provides some existing evidence of policy mechanisms that are effective under certain conditions, which deserves revisiting and updating to inform policy approaches going forward[1].

## Conclusion

'Crops that nourish' is an ambitious concept, and a call to action. It prioritizes local needs and agency, human and environmental health, co-creation between farmers and researchers, transdisciplinary collaborations and PAR. It demands the research community to champion systemic change guided by clear impact pathways rooted in locally defined problems and solutions, informed by consumer preferences, and supported with behaviour change and policy approaches to shift and grow demand.

Farmers and communities must set priorities and join with researchers in technology development to pursue clear value propositions. Several directions for future research are also important including better understanding of consumer demand, consumption and nutritional impacts and possible soil health impacts. Government participation is necessary to align policies. Yet government resources alone are insufficient; private sector investment (including farmer organizations/cooperatives) will be necessary to advance opportunity crop cultivation and consumption at scale. Realizing this vision is possible but requires inventive collaboration and expanded capacities.

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## Competing interests

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