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Farmer research networks in principle and practice

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ABSTRACT

In 2013, the Collaborative Crop Research Program (McKnight Foundation), initiated support for farmer research networks (FRNs). FRNs were envisaged as a general approach to networked participatory research aimed at supporting the agroecological intensification (AEI) of smallholder farming in ten countries in Africa and the Andes region in South America. The 30 FRNs ranged in size from 15 to more than 2,000 farmers. Rather than imposing a rigid FRN model, the programme used principles to guide action and reflection. The principles concerned ways of working with farmers, conducting research, and networking. This approach made it possible to reflect on how principles were interpreted, implemented, and used to guide learning in different contexts. This paper reports on insights gained from facilitated learning from 2013–2019 and focuses on subsets of diverse FRNs. Of the 30 FRNs supported, four were analyzed at some depth, reports and interviews were analyzed for 16, and a survey was conducted for 21. Relying on principles rather than an operational model has allowed for their progressive application, as participatory processes, farmer engagement, organizational capital, trust, and networks are built. Any reduced clarity and coherence seem outweighed by greater adaptability to context and resulting creativity.

KEYWORDS

Agroecology; principles; farmer research networks; learning; participatory; agency; engagement; systems

Introduction

Smallholder farmers across the globe face diverse challenges related to climate change, natural resource degradation, and other factors (e.g. Lema & Majule, 2009). Enhancing farmers' ability to access and adapt agroecological (AE) innovations can improve their productivity, food security, and resilience (HLPE, 2019; van den Berg et al. 2020). Although research and outreach to support agroecology have been limited to date (Biovision, 2020; Vanloqueren & Baret, 2018), interest exists among diverse stakeholders involved in agricultural development to identify ways of advancing AE transitions.

Agroecological intensification (AEI, defined here as improving farm and system performance through the implementation of AE principles) requires the adaptation of general principles to the vast diversity of local agricultural systems. This, in turn, calls for collective or coordinated actions involving problem-solving and collaborative learning processes, which often require strengthening farmer agency (HLPE, 2019; Restrepo et al., 2014; Waters-Bayer et al., 2010). A number of approaches have enabled collaboration among farmers, researchers, and development organizations to enhance innovative potential over the past three decades (e.g. Braun et al., 2000; Chambers & Ghildyal,

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1985; Hellin & Dixon, 2008; Méndez et al., 2017; Tchuwa, 2020; Waters-Bayer et al., 2010; Weltzien et al., 2019). These generally involve participatory research, which is often intensive and localized, and therefore small in scale.

An exception is the farmer field school (FFS) model, which has been implemented on a large scale in diverse settings by a range of partnerships since the the Food and Agriculture Organization (FAO) developed the approach (Van de Fliert, 1993). Tens of thousands of experiments have been conducted through FFS, and the approach emphasized collaborative learning. Little work has been done, however, to synthesize and share the evidence gathered (Van den Berg et al., 2018). In some recent work, large-scale participatory research has been undertaken with the aid of simple experimental designs that can be implemented by large numbers of farmers (Van Etten et al., 2019). To date, these approaches have been led by researchers and have not emphasized farmers' learning and agency.

The approach presented here aims to enable large-scale farmer participation in AE research and development in a way that enhances the agency of participants, bringing together the advantages of farmer-participatory research, large data sets, and a broad focus on AEI. Given that formal research organizations in settings with limited financial and human resources face significant constraints to reaching millions of smallholders, it seemed promising to support large networks of farmers (extant or possible) to collaborate with scientists and rural organizations, the objective being to generate the experience and knowledge needed to support AE transformations.

The concept of farmer research networks (FRNs) was proposed as a means for achieving these goals (Nelson et al., 2019; Nelson & Coe, 2014). A FRN was envisaged as 'an association of farmer groups, working together with research and development organizations to facilitate access to technical, institutional, and financial support, which engages in research and is networked so as to share information and data' (Nelson et al., 2019). This paper reports on the experiences from 2015–2019 of a research programme, the McKnight Foundation's Collaborative Crop Research Program (CCRP), that is working through FRNs.

Context

For more than 25 years, the CCRP has been supporting agricultural research in sub-Saharan Africa and Latin America. Since 2004, research projects were funded in regional clusters that have operated as communities of practice (CoPs). Beginning in 2012, the programme leadership began to articulate the hypothesis that a FRN approach would enable stakeholders to implement research that was both more participatory and more effective in advancing AE knowledge and practice. The approach was inspired in part by a shared commitment to farmer-centered research (Freire 1998), by experiences with farmer field schools (e.g. Nelson et al., 2001), and by participatory action research (Méndez et al., 2017). The approach also responded to learnings and frustrations experienced through the prior years of work as a grantmaking programme seeking to contribute to AE transitions (Nelson & Coe, 2014).

FRN establishment

In 2013–2015, scoping studies were conducted in the countries corresponding to the eastern and southern Africa CoPs (respectively: Uganda, Kenya, and Ethiopia, and Tanzania, Malawi, and Mozambique). These studies were conducted by knowledgeable individuals based in the respective regions and were intended to help the programme identify organizations with aligned interests that might contribute to FRN development. The CCRP regional teams serving the West Africa and the Andes CoPs used their regional networks to identify potential FRN projects.

In 2014, the McKnight Foundation provided grants to implement the FRN approach in a range of contexts. In some cases, FRNs evolved from existing research projects that may or may not have focused on participatory approaches but were aligned with the FRN concept. These projects either adapted their ongoing participatory work as a FRN or added a new component in order to develop a FRN. In other cases, FRNs were developed in collaboration with organizations whose work was strongly aligned with the CCRP and that had the institutional and social capital needed to do participatory, farmer-centered AE research. More than 30 FRN-type projects were supported during the period 2015–2019. The number of farmers engaged ranged from a few dozen to thousands (CCRP 2018). Some projects involved only researchers and farmer groups, while others engaged local government, farmers' organizations (FO), non-governmental organizations (NGOs), agricultural input suppliers, and others.

A principles-based approach

The CCRP leadership team articulated a set of principles (Box 1) to help guide project implementation.

In this paper, we present the results of an analysis of how FRN principles were operationalized in a number of projects over a five-year period. We highlight key learning points related to enabling farmer engagement and co-creating locally relevant research that is of general scientific significance. We also describe processes, drawing from practical experience of building well-functioning networks to advance AEI.

Box 1. FRN principles

1. Diverse **farmers** participate in the whole research process.
    1. Farmers co-create the research agenda.
    2. Farmers are engaged throughout the research process.
    3. Farmers from marginalized groups have meaningful representation in the network.
    4. Farmers strengthen their capacity to learn together.
2. **Research** is rigorous, democratized, and useful. It is focused on AEI knowledge creation that provides practical benefits to farmers based on their social and biophysical contexts.
    1. Research effectively addresses farmers' problems and opportunities and is continually adapted based on FRN members' reflections on their experiences.
    2. Co-developed research plans are formalized through an agreement of all parties that covers principles, rules of engagement, and responsibilities.
    3. Research is based on sound, appropriate, and participatory designs and protocols.
    4. Relevant local, indigenous, and farmer knowledges are fully integrated into research.
3. **Networks** are collaborative and facilitate learning and knowledge-sharing.
    1. Networks support learning and knowledge-sharing among all members.
    2. Networks are made up of connections among differently positioned actors and encourage the flow of learning throughout the network.
    3. Networks facilitate learning and knowledge-sharing among farmer groups and within communities.
    4. Network members engage in iterative reflection and planning to guide network activities.

Principles are statements that provide guidance about how to think or behave toward some desired result and are particularly suited to navigating complex, dynamic situations (Patton, 2018). Unlike a rigid model, principles are not prescriptive; instead, they allow for a diversity of forms and can be operationalized in different ways in different contexts. Importantly, the principles are used as a tool for evaluation by examining whether they are actionable, being followed, and leading to desired results (Patton, 2018, p. 3). While commitment to the principles was integral to FRN development, the principles evolved as practice led to shifts in understanding. The principles were formally revised after a couple of years of implementation. Those shown in Box 1 are the result of that revision.

The first principle addressed the need for a farmer-centered approach to agricultural research and development that improves farmers' agency and empowers farmers to participate in collaborative learning processes with other actors. There are both ethical and practical reasons to engage diverse farmers in FRNs. First, the McKnight Foundation has a commitment to diversity, equity, and inclusion. The programme team expected that farmers' participation throughout the research process would ensure relevance of the work to farmers' needs and interests as well as valuing a range of perspectives and forms of knowledge. Second, every stage of the research process involves decisions with a variety of implications (including allocation of resources such as time and effort), and farmer input is critical to ensuring mutual understanding and informed consent to collaborate. Third, if FRNs engage diverse groups of farmers, the research is more likely to take into account a broad range of needs and contexts; otherwise, research projects may engage with nonrepresentative samples (such as wealthier or male farmers only) and thus produce biased findings. It was hoped that fostering strong farmer participation in co-designing research would give farmers a sense of ownership that would lead to continued implementation and innovation to advance AEI.

The second principle addresses calls for research that is practical and useful to farmers while being conducted with sufficient rigour to produce credible evidence of relevance to agroecology. This goes beyond the search for 'the best' option to an approach that emphasizes innovation based on understanding of AE principles, such that farmers and their counterparts are able to refine practices that work for them in their specific social and biophysical contexts. The research-related principles necessitate adapting study designs over time based on reflection with farmers, through research plans that are co-developed in alignment with the principles of farmer engagement. In addition, the research principles call for a recognition of various forms of knowledge, including local or indigenous knowledge as well as scientific knowledge from various disciplines (Altieri, 2004; Gliessman, 1997; HLPE, 2019; Méndez et al., 2013; Méndez et al., 2017; Putnam et al., 2014). The idea of cognitive justice is relevant here; authentic participation requires that diverse epistemologies and methodologies are given attention and respect (Chandanabhumma et al., 2020; Coolsaet, 2016; Pimbert, 2018).

The third FRN principle addresses the importance of networks in sharing farmer innovations and knowledge on agroecosystems. This is critical because agroecology and food security often require collective efforts that can affect changes at a population, landscape, or ecosystem level. Researchers, farmer groups or federations, NGOs, large development projects, and other stakeholders such as local government and the private sector can form collective resources to support these processes. Networks can serve as structures for achieving both participation and scale, involving a broad range of stakeholders in generating knowledge as well as sharing the learning and resulting options with large numbers of farmers and other actors (e.g. Berthet & Hickey, 2018; Isaac et al., 2007; Warner, 2007; Wu & Zhang, 2013). These and other authors underline the importance of paying attention to social connections and information flows among farmers, of building effective networks that can help circulate learning and innovations, and of involving stakeholders that can be instrumental in fostering these colearning processes (Francis et al., 2020).

Methods

Sources of information on FRNs

Multiple sources of information were used in this analysis of FRN principles-based learning. An initial source was generated through the CCRP's FRN working group (FRN-WG), which was formed in 2015. The FRN-WG has held about 10 meetings each year since then, allowing participants to discuss and document emerging issues, programme developments, project work, and other topics. In 2018, the FRN-WG carried out a simple inquiry to document how FRNs were evolving and changing over time. Representatives of 21 project teams completed a survey with questions concerning size, growth, partner organizations, methods of accessing and sharing information, types of information shared, scope of project activities, and themes such as the purpose of the FRN, funding sources, leadership, and vision for the future. This data provided insights into FRN development and, thus, context for the analysis.

The CCRP's integrated monitoring, evaluation, and planning (IMEP) processes tracked the activities and outcomes of all projects, including FRNs. In addition, from 2015–2017, the IMEP team (a small group of professional evaluators) led an in-depth process involving four FRN project teams (one from each region). This process focused on the ways in which the principles were shaping FRN work and being revised by it. Participants provided written information to document targeted learnings. Said information included tables of activities and observations against each of the three main FRN principles and for different stages of the research cycle. They shared their findings during monthly virtual meetings in which project actors made presentations about their FRN work and discussed related issues. They also reported on tools they used or developed that could be useful for others working in FRNs. Finally, two of the authors carried out interviews with the participants to gather additional insights.

To follow up, in 2019 the same two authors conducted interviews with a dozen key FRN project leads. This provided insights from a broader subset of FRNs into the same themes as for the previous process: a) how each principle was interpreted in the project context, b) how it was used to guide decisions, activities, or approaches, c) tools developed to help translate principles into practice, d) challenges encountered in implementing the principle and how they were dealt with, and e) what project actors learned about working with each of the principles. These conversations were recorded, transcribed in their entirety, and collated by principle and sub-principle.

Analysis

Our analysis focused on a subset of the projects: Of the active FRN projects in the period covered (2015–2019) we had sufficient, robust information from 16 of them to draw lessons on the process of implementing the FRN principles (Table 1). We considered only projects for which we had both written project reports and more in-depth qualitative information on how, from an interview, site visit, and/or project presentation, the principles were understood and implemented.

The data and information from the additional 2019 interviews and from project reports were compiled, collated, and reviewed by principle and sub-principle from the two-year process with the four FRNs. This allowed us to identify inductively several themes related to the effects of working with the principles. A cross-case thematic analysis made it possible to

Table 1. Overview of FRN projects included in analysis.

Project Name Lead Organization Country Link	Origin & Network	Project Focus
AEI in Burkina Faso NGO: Groundswell Burkina Faso https://www.ccrp.org/grants/aei-in-burkina-iii/	Preexisting project, aligned Large (thousands of farmers), preexisting, NGO-based	Systems-oriented approach to AE to generate options to address priority problems
Bambara Groundnut FRN Research: INERA (*L'Institut de l'Environnement et de Recherches Agricoles*) Burkina Faso https://www.ccrp.org/grants/bambara-nut-frn/	Preexisting project, new component Large (thousands of farmers), new federation of women	Enhancing Bambara groundnut productivity in Burkina Faso
Best Bets Malawi Research: LUANAR (agricultural university in Malawi) and Natural Resources Institute (UK) https://www.ccrp.org/grants/best-bets/	Preexisting project aimed at improving soil fertility, FRN as new component Small, new, community-based	Sustainable agriculture and livelihoods within maize-legume farming systems
Drylands Research: University of Eldoret, Kenya https://www.ccrp.org/grants/drylands-farmer-research-network-frn-project/	New, funded as a FRN Small, new, community-based	Rehabilitating degraded lands for agricultural activities Initial work focused on reducing erosion and managing gully formation; later work has focused on introducing crops.
Farmer Knowledge Mali, Burkina Faso NGO: AMEDD (*Association Malienne d'Eveil au Développement Durable*) https://www.ccrp.org/grants/farmer-knowledge/	New, funded as a FRN Large, preexisting, led by a farmer organization	Farmer-led research and extension, farmer-researcher interactions
FIPS Village-Based Agricultural Advisors Kenya, Tanzania NGO: Farm Input Promotions Africa Ltd. (FIPS) https://www.ccrp.org/grants/fips-village-based-agricultural-advisors/	New, funded as a FRN, organization aligned Large (thousands of farmers), preexisting, NGO-based	Testing and disseminating locally adapted AE options
FRN Legume Integration Tanzania NGO: Research, Community, and Organizational Development Associates (RECODA) https://www.ccrp.org/grants/frn-legume-integration/	New, funded as a FRN, organization aligned Large (thousands of farmers), preexisting, NGO-based	Knowledge on intercropping of maize with pigeonpeas and lablab
FRN-NGO Kenya NGO: AGRISS https://www.ccrp.org/grants/frn-ngo-2/	New, funded as a FRN, created as an umbrella to five local NGOs Large (thousands of farmers), new and preexisting, NGO-based	Improving farm systems in sorghum-growing communities
FRN-Uganda Uganda NGO: People's Knowledge Women's Initiative https://www.ccrp.org/grants/frn-uganda-ii/	New, funded as a FRN, organization aligned Large, preexisting, NGO-based	Managing pests and diseases of cassava and cowpea
Networking4Seed Mali Research: ICRISAT https://www.ccrp.org/grants/networking4seed/	Preexisting project, aligned and extended Large (thousands of farmers), preexisting	Seed systems for sustainable seed dissemination of legume and sorghum varieties
Organic Peanut FRN Bolivia NGO: *Fundacion Valles*	New, funded as a FRN Small, new, community-based	Managing pests and diseases in organic groundnuts

(*Continued*)

Table 1. Continued.

Project Name Lead Organization Country Link	Origin & Network	Project Focus
Pathways to AEI Mali Research: Wageningen University https://www.ccrp.org/grants/pathways-to-aei-iii/	Preexisting project, aligned Large, preexisting, FO-based	Identifying AEI options that are tailored to farmers' multidimensional and multiscale contexts
Quinoa FRN Bolivia NGO: Proinpa https://www.ccrp.org/grants/quinoa-iv/	Preexisting project, adapted FRN approach Small, selected farmers	AE alternatives for the sustainable production of quinoa in Bolivia
Sustainable AE Crop Protection Malawi, Tanzania Research: Natural Research Institute https://www.ccrp.org/grants/botanical-pesticides-ii/	Preexisting project, adapted a FRN approach Small, expanding through NGOs	Safe and effective pesticidal plants for AEI (botanical pesticides)
Women's Fields Niger FO: FUMA Gaskiya Farmers Federation https://www.ccrp.org/grants/womens-fields-iii/	New, funded as a FRN Large (thousands of farmers) organization, preexisting, led by a farmer organization	AEI of women's fields (enhancing soil fertility using locally available resources, systems diversification, labor-saving techniques)
Yapuchiris Bolivia NGO: Prosuco https://www.ccrp.org/grants/yapuchiris-iii/	Preexisting project, aligned Small, preexisting network, expanding over time	Yapuchiris ('Wise Farmers') plus local climate knowledge

see how each principle was interpreted and internalized by project actors and addressed in project activities. This helped to highlight key learning points as well as challenges to the implementation of each principle, along with experiences and examples, some of which are quoted in the results below.

Next, we compiled basic information from each project to identify additional patterns across projects. This referred to the type of lead organization, origins of the project, size of the network, and number of AE components the project addressed. We developed scales for each principle and sub-principle to better determine significant trends. We used the resulting matrix of FRN projects to contextualize the more in-depth qualitative data described above, looking at characteristics such as project origin or lead organization to help understand variation without, however, assigning attribution. We used these in the learning described below to provide insights from different projects and their contexts.

Results

Learning is presented in three sections corresponding to each of the three principles related to farmers, research, and networks. Examples are provided by FRN in an appendix table.

Learning about working with farmers

The first set of FRN principles relates to farmer engagement. FRNs engaged with their members in different ways depending on structure and leadership and the history of the network. Some consistent lessons are listed here, and relevant findings are described below for each point. ('LF' refers to learnings about working with farmers.)

LF1. Leveraging existing relationships facilitated farmer engagement.

LF2. Achieving meaningful representation of marginalized populations in the network required an understanding of the complex power dynamics within and between communities.

LF3. All stakeholders needed to change their mindset about the role of farmers, be flexible about roles, and build capacity for farmers' roles to change over time.

LF4. Trust among stakeholders was key, and building trust took time.

LF1. Leveraging relationships for farmer engagement

All of the FRNs had mechanisms to engage farmers that built on existing relationships. These ranged from leveraging the relationships researchers and

agricultural extension agents had with farmers, to working with NGOs and the farmers with whom they had relationships, to working with (and sometimes strengthening) the relationships farmers had amongst themselves.

Of the 16 projects in this analysis, eight were developed based on existing research projects and eight were funded specifically to develop and implement a new FRN. Of those connected to an existing project, five were already aligned with the FRN principles and did not make major changes, continuing to work with the same farmers; two added a FRN component onto an existing project and drew on the working relationships with the farmers to recruit additional farmers into the FRN; and one adapted a non-FRN design to develop a FRN, again drawing on the existing farmer base.

While the existing research projects were headed by different types of organizations, all but one of the new projects that were funded specifically to develop a FRN were headed by non-governmental organizations (NGOs) and farmer organizations (FOs). FRNs led by NGOs and FOs tended to draw on their existing relationships within communities. In contrast, many of the projects headed by research institutions had to find ways to connect with community networks in order to broaden their farmer base beyond the farmers with whom they had a history of working. Some did this by working through existing clubs or partnering with existing large farmer federations.

LF2. Representing marginalized populations

Ensuring that marginalized populations had meaningful representation (ideally engagement) in the FRN was considered important in developing knowledge and practices that would provide options to farmers with low resources. For the NGO-led FRNs, their history of working with marginalized groups (the poor and very poor) made it easier to reach farmers who might otherwise be overlooked or excluded.

In order to understand representation of marginalized populations, many projects constructed farmer typologies. The aim was to assess and facilitate participation of farmers from different categories (for example, as defined by wealth, social status, or gender). Some focused on the barriers to participation by marginalized groups, with several specifically examining the underlying power dynamics within populations that influence participation. Some projects aimed to include as many and as diverse farmers as possible. Others focused on specific topics of interest to the project team that organized the FRN and recruited farmers with interest in those topics.

Another strategy was for participating farmers to share the learning with the more marginalized. This farmer-to-farmer learning was noted in many projects. However, because it relied on informal social processes that varied from one context to another, it did not guarantee that marginalized groups were represented, included, or benefited from FRN learning processes.

Most projects conducted analysis around the participation of women farmers. Since women were a marginalized group in most areas in which FRNs operated, many projects noted the importance of strengthening women's participation and found different ways to do so. Women and men often had different production priorities, constraints, and ways of working, and, thus, had distinctive needs or preferences in terms of varieties, management practices, inputs, and more (Weltzien et al., 2019). As social organizations, FRNs also provided a space where women's unique roles and contributions could be supported and their challenges addressed (e.g. lack of control over key resources such as land or objection of male relatives to a woman's participation).

LF3. Changing stakeholders' mindsets about the role of farmers

One of the greatest challenges to farmer engagement was the legacy of conventional top-down research and extension practices. Ingrained historical social, cultural, and educational norms have perpetuated complex and intersecting dynamics that have marginalized farmer agency and knowledge while favouring that of researchers, professors, scientists, extensionists (generally male), and those with formal education and high levels of literacy in a dominant (colonial) language. As such, farmers had been taking advice from various types of officers for years and often lacked the social legitimacy, personal confidence, and skills to engage as equals.

Shifting these dynamics required changes in the mindsets of researchers as well as farmers. All had to be willing and able to engage in new types of relations. Many FRNs found that they had to choose researchers who were committed to participatory processes where the intention was to build more horizontal relationships among equals.

The first FRN principle requires that farmers co-create the research agenda and are engaged throughout the research process. Many FRNs noted that this is an iterative and evolving process, and that engaging farmers as full participants took time. Many project actors also pointed to the need for extension workers and other facilitators to change their habitual roles, specifically from a more didactic mode to a more collaborative or coaching mode.

Individual facilitators embodied these ways of engaging with farmers with various degrees of ease. Training was often requested for strengthening the needed capacities. In West Africa, for example, leadership training was offered so that all types of stakeholders (researchers, development agents, farmers, and students) could develop 'soft skills' to co-create and negotiate research designs, which was found to be essential to the principle of engaging farmers in the whole research process (Tunezerwe, 2020). When researchers imposed overly elaborate study designs (for example, those requiring farmers to record detailed data), the results were generally less satisfactory than when farmers were given an opportunity to identify what they really wanted to observe and to determine how they would do it.

LF4. Building trust amongst stakeholders

The concept of trust is central to the lessons above. Implementing organizations observed that building trust is the single most important prerequisite for any research and development intervention and that it requires time and commitment, including the direct involvement and final approval of the grassroots organization. While this trust-building period can slow the initial progress of a project, the subsequent work can then advance quickly.

Learning about doing rigorous and relevant research

The second principle characterizes the research aspects of an effective FRN. While FRNs could be used for many types of research, those supported by the CCRP aim specifically to build AE knowledge that addresses farmers' problems and opportunities while being rigorous, participatory, and informed by the knowledge of all involved stakeholders. Key lessons are as follow: ('LR' refers to learnings about research.)

LR1. Co-creation fosters useful research and practical benefits for farmers, rooted in local context.

LR2. A flexible approach helps to adapt research methods to farmers' capacities and local circumstances.

LR3. Finding the 'right size' for each trial helps to identify repeatable options for different contexts and then to assess risks on a larger scale.

LR4. Integrating researchers' data analysis and interpretation skills with farmers' contextualized local knowledge can provide powerful insights on AE options.

LR5. Participatory research can lead to rich AE evidence and high-quality publications.

LR1. Co-creating research topics

In order for the research to 'effectively address farmers' problems and opportunities,' FRN stakeholders identified topics of relevance to their contexts. In some, initial discussions with farmers elicited issues or production problems that they considered important, and a process was then facilitated for negotiating a specific research topic. Methods included problem trees, agricultural calendars, interviews, and participant observation. In other FRNs, the topic was based on the expertise of the collaborating researchers and partners but farmers negotiated the specific focus.

To remain relevant by 'continually adapting based on experience and reflection,' FRNs implemented collective learning processes at regular stages throughout the research cycle. In some FRNs, this adaptation process resulted in a new research topic, while in others it led to a shift in focus within the same topic (e.g. adding a different treatment or variable). Interviews with project leads revealed that, as farmers gained experience and confidence with research, they had new questions and ideas for future experiments based on their own observations as well as the data analyses.

LR2. A flexible approach to participatory designs and protocols

With the inherent diversity of options and contexts, developing participatory study designs and protocols was found to require a balancing act between complexity and simplicity, given the need to keep things straightforward as FRNs began to operate. Simple experiments worked particularly well for projects

working with large numbers of farmers. In some FRNs, all farmers did the same trial, testing the same things in the same way, such as intercropping different varieties of sorghum with maize at a standard spacing. In other FRNs, a larger set of options was tested across a large number of farmers, as in the case of a suite of new sorghum varieties where more than a thousand farmers each tested a subset of the varieties. In still other FRNs, individual farmers chose to implement the trial in a variety of different ways, for example choosing among crops, varieties, spacing, and fertilization methods. This made data collection, analysis, and interpretation more complicated but supported farmer agency, local adaptation, innovation, and shared learning. It also challenged many researchers' beliefs on what constitutes valid research designs.

The participatory design provided an opportunity to do more farmer-relevant research and to contextualize the results. As farmers gained experience and, in some cases, received training, the quality of the data improved as did the understanding of research principles. Projects with fewer participants and smaller farmer groups were better able to accommodate more farmer initiative in adjusting protocols and implementing research plans.

All FRNs involved farmers in the design as well as, to varying degrees, the data collection, analysis, and interpretation of results. While FRNs generally tried to engage farmers in data analysis and interpretation, the extent to which this was possible varied. In many of the project contexts, farmers had low literacy rates and little culture of writing or recording information. In order to ensure both participation and rigour, most projects developed strategies by which farmers collected certain types of data while technicians, students, and researchers collected other types: generally data that required specialized skills or instruments. For farmers, data collection tools needed to be simple and practical, and many projects developed their own, often with farmer input and using familiar iconography (e.g. scorecards).

FRNs with large data sets and many different participants needed computer-based tools to aggregate the data and perform analyses, which required a data manager, while smaller projects could do this manually with farmers. Several projects used feedback sessions during which farmers provided their perspectives on factors that help explain results, which often yielded interesting insights (Falconnier et al., 2016). This meant building farmers' capacity to collect data and interpret results, which in turn required strengthening the capacity of researchers, farmer organizations, and NGOs to support these collaborative learning processes and adapt their own ideas on how it should be done.

Many projects developed visual tools for sharing results with farmers. This involved selecting the most relevant findings from the wider set of results, including contrasting outcomes in different situations, visualizing the data in ways that nonliterate farmers could easily understand, and facilitating discussion to interpret the findings.

LR3. Finding the right size for each trial

The initial aspiration of some members of CCRP leadership was for FRNs to conduct trials involving large numbers of farmers such that the specific options suited to different socioecological contexts could be identified (Nelson et al., 2019). The intent was to move beyond the one-size-fits-all thinking that has pervaded agricultural research (Vanlauwe et al., 2019). Some large-N trials have been conducted and have provided robust evidence while exposing increasing numbers of households to new ideas on an experimental basis, removing the distinction between 'research' and 'scaling' implicit in many approaches.

However, practical experience and reflection led to the realization that it was often not feasible, necessary, or desirable to conduct large-scale trials, at least without initial exploration of possibilities. Involving large numbers often required top-down arrangements, precluding deep farmer engagement and agency: True participation was better facilitated in smaller groups. Depending on the purpose of the research, different approaches were taken to identify the appropriate trial size (right N) while minimizing risk for farmers.

LR4. Integrating researchers' and farmers' knowledge

The research sub-principle stating that 'Relevant local, indigenous, and farmer knowledge are fully integrated into research' often meant adding options that farmers brought from their own practices, such as local crop varieties, management practices, or soil amendments. It could also mean adjustments to what was measured and how outcomes were assessed and interpreted. Niche differentiation was important in several cases: Farmers wanted to know

what worked for whom, when, and where. Integrating researchers' data analysis and interpretation skills with farmers' contextualized local knowledge can provide powerful insights on AE options, as has been seen in other cases (Barrios et al., 2012). However, this is an area that is often new to both scientists and farmers.

LR5. Participatory research can lead to rich AE evidence and high-quality publications

Although the formal analysis and publication of findings from participatory research can involve special challenges, it is possible to produce high-quality findings and outcomes (Bellon & Reeves, 2002; Viswanathan et al., 2004; Vom Brocke et al., 2020). Several publications from FRN projects have been cited here, and more exist or are in preparation. Conventional research productivity, as measured in publications, is clearly enhanced when projects involve academics, for whom publication is a priority. Individuals conducting research on behalf of NGOs and farmer organizations may lack the resources, capacity, and motivation to publish in academic journals. Instead, other ways of documenting and disseminating results are used, such as videos, website posts, workshop presentations, and other media that target a broader audience. It remains a challenge to effectively balance differing priorities and communicate learning from FRNs in ways that allow for people in different places to learn from each other.

Learning about the potential of networks

The third FRN principle highlights the importance of collaborative networks that facilitate learning and knowledge-sharing. This principle aims to enable the collective 'network of FRNs' to build an evidence base to support smallholder AE farming such that an individual farmer or local FRN has an increasingly powerful basis for solving problems and transforming systems for greater sustainability. The sub-principles counteract tendencies for one-way knowledge flow, knowledge to be held only by certain actors, or networks to be hierarchical. Analysis drew attention to the following lessons: ('LN' refers to learning about networks.)

LN1. Networks evolve to fit project context and needs.

LN2. Stakeholder complementarity and alignment are important in building strong and effective networks.

LN3. Knowledge-sharing in FRNs happens in both formal and informal ways and supports scaling.

LN4. Networks highlight the potential for collective action.

LN1. Networks evolve to fit project context and needs

The important differences among FRNs suggest that the network principle has been interpreted in a flexible manner. Network sizes ranged from small numbers to large (e.g. from 15 in a Bolivian network of 'Yapuchiris,' or farmers with recognized expertise, to more than 2,000 in several FRNs in Africa. The types of stakeholders typically included farmers and local researchers and sometimes international researchers, local government, private sector, or others. Some originated from preexisting projects, while others were newly formed as FRNs. Leadership was based in a research organization, NGO, or farmer organization. In short, networks were built to fit project context and needs.

LN2. Stakeholder complementarity and alignment

Stakeholder roles varied significantly across projects. In general, researchers, including students, provided support on study design and methodology and suggested AE options such as adapted crop species and varieties, botanical pesticides, and more. NGOs and FOs generally helped to create and maintain network connections, providing structure, personnel, and material assistance for FRN activities. Other partners or stakeholders, such as local government, provided further types of support to FRNs. The partnerships among different types of stakeholders brought different strengths to the work, sometimes leading to additional activities such as group purchasing, marketing, processing, or services. Conversely, the FRN often helped to strengthen and consolidate the capacity of partner organizations by contributing to leadership, research capacity, and training.

Some FRNs dropped potential partners when alignment was not strong enough or when it was feared that a stakeholder wanted to take advantage of farmer groups to promote its own interests or products. This points to the challenge of building healthy, effective networks in which stakeholders' interests are aligned with each other's and with project goals. Paying attention to and managing power relations

emerged as an important facet of network development and stakeholder relations.

LN3. Knowledge-sharing is both formal and informal

Farmers who are engaged and invested in the work are more likely to use the insights generated. Yet working with farmers across sometimes large geographic areas presented challenges to shared learning. In most cases, farmer groups were part of community- or village-level groups, which in turn were linked to other communities and eventually to larger administrative units such as counties. Most often, agricultural technicians, local facilitators, or village-based advisors worked with farmer groups on implementation and data collection, connecting them to other groups. Representatives, or delegates, for these local networks participated in higher-level discussions and planning, bringing the learning back to the local farmer groups.

Learning circulated among farmers in both formal and informal ways. Informal knowledge-sharing took place as farmers interacted with each other during collective work or impromptu visits where they could observe trial results. Formal sharing, on the other hand, took place during network activities organized by projects, such as annual or semiannual meetings, exchange visits, field days, and capacity-building workshops. The scale and number of farmers who could attend such events were limited, however. Sharing required strong mechanisms for networking from the village scale to district or county levels. In some FRNs, farmers with smartphones created WhatsApp groups to share news, information, or questions.

LN4. Networks enable collective action

Networking emerged as an important pathway to collective action, which was essential for research problems that required community-scale participation. These sorts of projects often had systems or landscape level changes as their ultimate goal.

Discussion

This paper reports on the experiences of a grantmaking programme that conducted an initial cycle of investment and support in an approach to networked participatory research aimed at supporting the agroecological intensification (AEI) of smallholder farming in four regions where food insecurity is a pervasive challenge. Rather than imposing a rigid model for farmer research networks, the programme used principles to guide action and reflection. This provided opportunities as well as challenges. The opportunities included the possibility of learning from diverse FRNs. Here, we report on insights gained from facilitated learning with 16 FRNs in eastern, southern and west Africa, and the Andean region of South America. Relying on principles rather than an operational model sometimes provided less clarity and coherence than might have been the case if a specific model had been adapted across FRNs, but it unleashed considerable creativity from our nascent network of FRNs.

Decades of agricultural research and development engaged with farmers mainly as passive recipients of technology, occasionally as testers, and sometimes as learners. While mainstream research has been driven and executed by professional researchers, various forms of participatory research and extension have been developed over decades as well, yielding many models and approaches that could be drawn upon and adapted. Calls continue to be made for a paradigm shift toward democratized research by, with, and for food producers, which produces transformative knowledge for agroecology, food sovereignty, and biocultural diversity (e.g. Pimbert, 2018). The vision for FRNs is intended to address some of the criticisms that have been levelled at participatory research, build on prior approaches, and take advantage of some of the opportunities presented by information and communications technologies to advance AEI (Nelson et al., 2019). The FRN principles cited above are key to the process.

In the broad context of agricultural research, approaches that engage with farmers as partners in designing and conducting research on topics they have prioritized remains marginal (Van de Gevel et al., 2020). Often, such research is highly circumscribed and localized, providing limited benefits for other contexts, suffers from limited alignment between the interests of researchers and farmers (Bentley, 1994), and does not always take a holistic approach to agroecology as its focus. Both conventional and participatory approaches struggle to contend with the complexities involved in AE systems transformations (e.g. Eksvärd, 2010). Additionally, some research suffers from tokenism, where lip service is paid to participation without truly engaging farmers' concerns and perspectives (Ollenburger et al., 2019).

As noted above, a variety of creative participatory research efforts have been underway for decades with some success. A number of these focus on AE transitions (e.g. Braun et al., 2000; Derero et al., 2020; Méndez et al., 2017; Nelson et al., 2001). FRNs can be part of a broader shift in farmers' roles from passive beneficiaries of technologies to equal partners or leaders in a research process, expanding the power of research through wide-scale participation. FRN principles provide a framework for making that shift. The results presented above highlight the importance of changing the mindsets of all stakeholders about the ability of farmers and their organizations to play active roles in research processes (Kidd & Kral, 2005).

FRN partnership structures

As has been found in the field of public health, building trust among stakeholders was key to achieving progress and authentic participation (Lucero et al., 2020). It took time to build trust among partners, and it was helpful to leverage existing relationships with and among farmer groups and local organizations. This facilitated farmer engagement while rooting the research in local contexts, bringing in marginalized farmers, and connecting to the wider community. It also made it possible for FRNs to work with large numbers of farmers in some cases and for researchers and research organizations without extensive social capital of their own to efficiently connect with extensive farmer networks.

Although agriculture research projects are typically led by researchers, the FRN experiences reported here demonstrate that FOs and NGOs can be effective lead organizations, as they often have the infrastructure needed for reaching farmers and their representative organizational structures. They have the social capital, organizational capacity, in-depth knowledge of the contexts in which they work, and extension staff that can be trained to facilitate with participatory methods if they do not already have these skills. The networks in which they are engaged make it possible to reach large numbers of farmers who can participate in research projects. In many cases, their organizational capacity needs to be supported to play these new roles, including the processes involved in research. Co-learning for farmers, NGOs, extension, and researchers entails new ways of talking to each other, making decisions, and sharing power.

Scaling

A key aspiration of the FRN vision was the potential of large-scale farmer participation through the combination of farmer networks, the application of digital communications technology, and global networking (Nelson et al., 2019). The extensive social and human capital of rural organizations proved essential to reaching large numbers of farmers. The use of digital technologies has been increasing in several FRNs, with dedicated apps being used by some. However, no single software application has been broadly applied across FRNs to date. One of the projects supported through the CCRP developed a software platform to crowdsource data from large farmer networks (Van Etten et al., 2019). Although this approach was shared with FRNs at training events, none adopted the software extensively.

Working with principles

As the FRN principles were developed, they were emphasized from farmer to research to network. The first principle, which calls for the engagement of diverse farmers across the whole of the research process, reflected the programme's assumption that establishing social capital and trust should logically precede the capacity to conduct research and that larger networks could be built only after local ones had established themselves. It challenged stakeholders in the agricultural R&D process to elevate the role of farmers from recipients of learning, providers of data, and/or implementers of researcher-controlled experiments, to true partners in the R&D process. When this principle was operationalized, it shaped the way that research was designed and implemented (Principle 2) as well as the interactions within a research network (Principle 3). The principles were so interconnected that they were often difficult to separate both practically and conceptually. For example, when diverse farmers participated in the whole research process (Principle 1), research was more likely to provide practical benefits to farmers based on their social and biophysical contexts (Principle 2). As farmers strengthened their capacity to work together (Principle 1d), networks were better able to support learning and knowledge-sharing among all members (3a).

The development and consolidation of FRNs as effective knowledge co-creation networks was a gradual process. The principles have been applied

progressively, initially emphasizing those that the implementing organization could best address with its experience and expertise, and later addressing the remaining principles as capacity expanded. Building partnerships with organizations with specific, complementary expertise helped to accelerate this process. Indeed, it is becoming evident how important the network dimension is to systems transformation.

Ongoing challenges and opportunities

Many growth areas for the FRN approach exist. Aside from basic operational challenges such as improving cross-learning among FRNs, frontiers include the integration of different ways of knowing, producing knowledge that has both global and local relevance, and doing systems-oriented research.

Integrating different ways of knowing

The aspects of local, traditional, and/or indigenous knowledge that were integrated into most projects were agronomic practices, and they were usually integrated alongside more conventional options. Hence, the emphasis was often on the technological dimensions of local knowledge. Equally valuable for AE are socially and culturally embedded ways of learning, innovating, and spreading ideas as well traditional solidarities and ways of communicating. Although many projects aspired to integrate farmer knowledge in their work, only a few were doing so in any substantive way. One example was in Bolivia where strong political support exists for long-standing indigenous traditions. Transdisciplinary research teams including biophysical and social scientists and their research methods and perspectives seem necessary for this work. As Kloppenburg has argued, 'The problem is not one of choosing between scientific knowledge or local knowledge, but of creating conditions in which these separate realities can inform each other.' (1991, p. 540). He adds that 'a truly alternative agriculture must be based on a truly alternative science that articulates multiple ways of knowing.'

The challenge of producing globally and locally relevant knowledge

Given the mix of stakeholders involved, FRNs face the challenge of balancing the scientific imperative of producing research results of general scientific relevance and the local imperatives of solving problems and improving lives. For researchers who study the development of agroecology, there is a need to 'better link researcher-oriented approaches and support-oriented approaches, to design local setups that will help farmers and other stakeholders in the long-term process of redesigning farming systems' (Lacombe et al., 2018). This requires in-depth discussions between all project actors, as equals, from the outset and mechanisms for balancing different priorities.

While local learning among farmers and relevant knowledge that contributes to broader understandings are both important and not necessarily opposed, these objectives often stood in tension. Some FRN research designs were focused more on demonstration or training than on producing new scientific knowledge, as some believed that farmers should not experiment on something that might not work. Ideally, FRNs can conduct locally relevant research with the support of scientists who can explore and clarify the underlying mechanisms and processes that explain the observed patterns, effects, or behaviour. Conducting research across contexts can better reveal the underlying mechanisms and processes, helping to scale AE to other contexts.

The challenge of systems-oriented research

Over the period of this study, the CCRP began to shift its focus from research on components of farming systems to supporting broader systems change. As Stone observed, recent approaches to agricultural knowledge production have overstated the heuristic value of experimentation, which 'tend[s] to be most instructive on atomized components of the enterprise, with the more crucial aspects of farm management being too complex and uncontrolled for effective experiment. Formal research thrives on atomizing agricultural production by parsing the farm into commodity-friendly subsystems that are incommensurate with actual farm decision making' (Stone, 2016). This characteristic was also noted by Eksvärd (2010) based on participatory work in Sweden.

Indeed, many FRN projects began with a focus on experimental trials, often testing technologies of interest to research partners. In fact, many people in FRNs, including farmers, seemed to equate 'research' with a small plot trial. While such trials produced valuable information for farmers, the potential for transformative change was limited. As the FRNs have

matured, they have typically taken on more aspects of a problem, recognizing, for example, the interconnections between plant health and soil health and the need for greater emphasis on building the latter. Testing crop varieties was often an entry point, with later focus on more diverse aspects of the production, consumption, and marketing aspects of the food system.

A FRN approach to AE is highly suited to this challenge. It can be used to support research and action at a systems level (such as a landscape, agroecosystem, or food system). Working in networks that include actors besides farmers may catalyze and strengthen systems thinking. Networks create opportunities to link farmers to other actors, bringing in perspectives, knowledge, and technologies from others in the farming and broader food system.

While it remains a challenge to shift research in this direction, some FRNs were using a systems lens even in research focused on components of the farming system. This was done by researching multiple components of the agroecosystem and supporting farmers in making informed choices about how to best sequence and combine a variety of AE techniques to suit their own needs, farming system, and resources. Additionally, some projects encouraged landscape-level management practices while others provided support for value chain research where different system components interact. All of these are considered to facilitate the gradual transition to a sustainable AE system.

FRN compared to other types of participatory research

The network principle, coupled with a systems approach to research for AE, distinguishes the way the CCRP has implemented FRNs as compared to many other participatory, farmer-centered action research approaches. While many foster farmer engagement and learning through a research process, most often the results are not shared through networks in a way that could make aggregation or synthesis possible or enable sharing of resources, protocols, tools, and more. In addition, networks can facilitate advocacy and policy influence because they engage a range of stakeholders, some of which may be research institutes or different levels of government. This is an area in which many researchers find it hard to engage and for which it will be important to gather evidence over time.

Conclusion: FRN for AE

FRNs are more a means than an end. They aim at applying AE principles to local contexts while building a knowledge base by and for farmers. Networks are essential for achieving this at a meaningful scale. By connecting complementary individuals and organizations, they can tackle specific problems and seek transformative change, potentially improving the quality of rural life through a multiplicity of roles. At a technical level, they can support data collection and management with large numbers of farmers, enabling the aggregation of large quantities of data from and about many different farming contexts. But this does not happen without strong social relations, technical support, and a commitment to AE transitions. The vision of AE farming is not well aligned with the standard recommendations farmers have received, which promote one-size-fits-all, input-oriented solutions. The FRNs established to date are beginning a journey that will require sustained commitment from diverse stakeholders and funders.

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Appendix

Table A1.

Project Name	Examples of Learning by Principle
AEI in Burkina Faso	***LN2:*** The FRN engaged traditional and municipal leaders as well as technical service agents in planning, assessing results, and training, thus expanding and strengthening its network.
Bambara Groundnut FRN	***LF2:*** The FRN focused specifically on women as a marginalized group. The team offered learning modules on leadership, self-knowledge, and negotiation in an effort to foster women's ability to participate in what became a federation of Bambara groundnut producers' organizations that put the entire women's farming system at the center of research. ***LR3:*** To explore options, the FRN did 'mother-baby' trials in which researchers managed a comprehensive test including all available options: the mother trial. In the baby trials, farmers chose one or two options to evaluate in their own smaller trials.
Best Bets	***LF2:*** To better understand and represent marginalized populations, the team conducted a participatory social and wealth ranking in FRN target villages. ***LR2***: Participatory designs were agreed upon through dialogue between farmers, researchers, and extension workers. Soil health improvement options were jointly generated and informed by formal research and indigenous knowledge. Farmers were involved in designing the layout of the experimental plots, including the selection of the comparison group/plot. ***LR3:*** Farmers tested different soil health improvement options on small plots first (0.01 ha or 10 ridges by 10 m length) to minimize farmer risk and identify promising options to test in their own fields. ***LR4:*** Farmers tested local knowledge such as spreading soils from anthills on degraded farm plots, placing experimental plots in fields with local fertilizer trees (e.g. *Faidherbia albida*), and rotating maize with a pigeonpea-soy intercrop as well as applying urine in maize plots to improve soil fertility. ***LN1:*** The network of stakeholders was relatively small and based in local communities. ***LN3:*** Farmers shared information as they interacted in or closer to experimental plots within their groups and villages. Farmers helped each other understand why options such as maize-doubled-up legume rotation were more effective than maize-single legume rotation in changing soil parameters (e.g. organic content). Farmers learned suitable crop husbandry practices from each other and how to adapt the experimentation principles to their contexts. Generally, there was more information-sharing within than across villages and gender groups. Due to cultural barriers, male farmers were more likely than women to reach out to farmers in other villages.
Drylands	***LF1:*** Farmer engagement was facilitated by key project researchers from the West Pokot community. ***LF4***: Researchers spent more than a year developing relationships with communities before beginning work on landscape rehabilitation. The farmers developed trust in the researchers, felt confident to express their points of view, and had a sense of project ownership. Social capital among farmer groups was strengthened, and a range of farmers from different age groups, community geographies, and farm types were highly motivated and saw the potential for rehabilitating their degraded soils and landscape. ***LN2:*** The county government helped to build sand dams as part of erosion control measures, bringing value to the network. ***LN3:*** Farmers used a merry-go-round method involving intensive collective work on a rotating basis among farms. As farmers spent time on each other's plots, they asked questions, made observations, shared information, and ultimately developed a shared vision for their landscape. Information from the FRN research was shared face-to-face and through observation in the field. ***LN4:*** Collective action was required to work at a landscape level. Farmers worked together extremely efficiently to construct terraces, sand dams, and other erosion control measures, making it possible for the community to see rapid benefits both biophysical and social.
Farmer Knowledge	***LR4:*** Farmers requested that the traditional way of intercropping, which consists of planting cereals and legumes into the same planting hill, be included among the options being compared.
FIPS Village-Based Agricultural Advisors	***LR3:*** To explore options, the team did small, simple trials as an initial test, a medium-sized trial for the more promising options, and a larger trial for successful options across a larger number of contexts. ***LN2:*** Network members provided services such as tree pruning, preparing, and spraying botanical pesticides.
FRN Legume Integration	No specific examples
FRN-NGO	***LF1:*** Farmer engagement was facilitated by bringing together five local NGOs with long-standing relationships with farmers. ***LR1:*** Co-creation led to an entirely new research topic (Striga control). ***LR2:*** The participatory design process led to adjustments in protocols: Farmers rejected square plots because they did not work in their fields. ***LR3:*** More than 1,000 farmers tested a suite of new sorghum varieties and were able to assess the performance of each line over a variety of environments. ***LN1:*** Under a new umbrella organization, the preexisting social capital of the five member organizations helped to build a broad network involving many farmers across a large area.

(*Continued*)

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Project Name	Examples of Learning by Principle
	LN3: WhatsApp groups were created to share news, information, observations, and more. Farmers called each other to discuss issues, send photos, or write messages.
FRN-Uganda	***LF1:*** Farmer engagement was facilitated because the lead organization had been working with the communities for many years.
	LN4: The aim to revitalize the local cassava seed system required collective action. The FRN had to shift its focus from individual farmers to a community campaign, combining the provision of clean planting material with collective phytosanitation action supported by community education and bylaws in partnership with local government.
Networking4Seed	***LF1***: Engaged a broader base of farmers through existing large farmer federations.
	LN1: The FRN grew out of an existing project on participatory crop breeding. The network approach was used to further develop seed systems, enhancing existing networks amongst farmers, seed producers, and seed marketing specialists. Building this network was facilitated by project actors' long-term experience working with farmers and other stakeholders. Their in-depth understanding helped them to build new networking structures important to the development of sustainable, culturally appropriate seed distribution systems. Such included the creation of local seed committees that decentralize decision-making processes and support horizontal interactions among groups of farmers as well as with researchers, development agents, and policymakers. The sophistication of the network enabled it to successfully produce and market hybrid sorghum seed of varieties selected by farmers.
	LN3: WhatsApp groups were created to share news, information, observations, and more. Farmers called each other to discuss issues, send photos, or write messages.
Organic Peanut FRN	***LF2***: Some more marginalized farmers (the poorest and most vulnerable) did not have the time or resources (e.g. land to use for trials) to engage. Instead, a smaller number of farmers who were naturally curious and locally recognized as 'researchers' were designated.
	LN1: The network of stakeholders was relatively small and based in local communities.
Pathways to AEI	***LF1***: Engaged a broader base of farmers through existing large farmer federations.
	LF2: To represent marginalized groups, the project developed activities specifically for women, such as a sheep fattening trial.
	***LR1*:** Collective learning processes and ongoing adaptation were made possible by holding farmer field days (joint visits of the trials by groups of farmers), feedback to present the results of the previous season, and planning workshops in the villages to plan the coming season's trials.
	***LR2*:** Involving farmers in interpreting results led to the insight that the wide variability in response to treatments was related to soil type and previous crop in the rotation.
	***LR3*:** To explore options, the FRN had small plots (four to eight treatments), demonstration trials for things that worked well on small plots, and tryout fields.
	***LN3*:** Knowledge was shared by holding local trials and demonstrations at the field level, farmer discussion at the farm level, training workshops and planning and feedback sessions at the village level, and field visits within and between villages with a broader range of stakeholders (but fewer of each category).
Quinoa FRN	***LR1:*** To co-create the research within the parameters of researchers' expertise, farmers were asked, 'What do you want to know or discover about quinoa varieties?' Farmers identified the need for varieties with higher yield, larger grain, and sweet taste, as well as varieties with different seed colors adapted for various biophysical and social contexts.
	LR2: To facilitate participatory interpretation, farmers manually plotted results onto a graph on a large piece of paper and discussed the results as a group.
	LN3: WhatsApp groups were created to share news, information, observations, and more. Farmers called each other to discuss issues, send photos, or write messages.
Sustainable AE Crop Protection	***LF1:*** It worked through existing clubs to engage a broader base of farmers than the lead organization had previously.
Women's Fields	***LF2:*** Project focused specifically on women as a marginalized group.
	LF3: The farmers' federation negotiated with researchers to work on priorities expressed by farmers, reversing the dynamic by which researchers set the terms of engagement. Although some initially expected that the FO would test technologies made available through the research partners, the FO-led FRN identified its own innovations, some of which have had high impact. Examples include the use of sanitized human urine as fertilizer, the use of seed balls to increase seedling survival, and partial weeding.
	LR2: The FO developed its own app for farmer registration and data entry. This facilitated data management and analysis but must be done by a central data manager rather than farmers. Facilitators used their smartphone app to show farmers the results with information about farmer type, plot, and soil type.
	LR3: More than 1,000 farmers tested the use of sanitized human urine, seed balls, and partial weeding in the Women's Fields FRN, demonstrating consistent benefits.
	LN2: In addition to research activities, stakeholders supported group purchases and offered workshops.
Yapuchiris	***LR2***: Yapuchiris, or wise/knowledgeable farmers, developed a highly visual recordkeeping tool that enables farmers to monitor weather as well as locally recognized biological indicators in the environment.
	LR4: The tool, Pachagrama, integrates indigenous and scientific forms of knowledge.