

Innovations in Seed Systems

Lessons from the CCRP-funded project “Sustaining Farmer-Managed Seed Initiatives in Mali, Niger, and Burkina Faso”

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Foreword

In 2012, The McKnight Foundation's Collaborative Crop Research Program undertook a series of case studies of some of the projects it has funded. The case studies were designed to provide insights on the projects' contributions, on impacts of the program and project interventions, and on lessons learned over the years. We chose the case study method as a way to combine qualitative and quantitative data in a specific context. We focused on utilization so that the program, grantee, and larger community can learn and improve research for development outcomes going forward.

Innovations in Seed Systems is the third case study in this series. The case highlights the complexity of issues and actors across the whole of a "seed system." Throughout the seed value chain, a multitude of opportunities exist for thoughtful funding in research and development to improve the performance of the overall system.

The report highlights elements of success in this important West African effort. The project contributed to a significant increase in farmer-managed seed production. It also succeeded in improving farmers' access to seeds, especially addressing the contextual constraints to variety adoption by offering low-cost, high-opportunity options via mini-packs of seeds. Inclusion of women in variety trials led to contextualized knowledge about new varieties, which in turn contributed to the positive impact on productivity, income, and nutrition at project sites.

The report also highlights challenges to be addressed in future funding and partnerships to achieve sustainability of the impacts. Equity, especially for women and the extremely poor, continues to be a key consideration. Entering into dialogues around these policies and rules will be important in the next phase of work.

We are pleased to share this report with others working in agricultural research and development, and hope that you will find the case study to be of value.

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ABBREVIATIONS USED IN THE REPORT

AGRA	Alliance for a Green Revolution in Africa
ASIWA	Alliance for a Seed Industry in West Africa
CAADP	Comprehensive Africa Agriculture Development Program
CCRP	Collaborative Crop Research Program
CGIAR	Consultative Group for International Agricultural Research
CILSS	Permanent Inter-States Committee for Drought-Control in the Sahel
CoP	Community of Practice

CPF	Confédération Paysanne du Faso
DAC	Development Assistance Committee (of OECD)
ECOWAS	Economic Community of West African States
FAO	Food and Agriculture Organization of the United Nations
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit (formerly: GTZ)
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit (now: GIZ)
IAASTD	International Assessment of Agricultural Knowledge, Science and Technology for Development
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IER	Institut d'Économie Rurale (Mali)
IMEP	Integrated Monitoring, Evaluation, and Planning
INERA	Institut de l'Environnement et de Recherches Agricoles (Burkina Faso)
INRAN	Institut National de la Recherche Agronomique du Niger
IPGRI	International Plant Genetic Resources Institute
ISSD	Integrated Seed Sector Development
ITPGRFA	International Treaty on Plant Genetic Resources for Food and Agriculture
M&E	Monitoring and Evaluation
MSC	Most Significant Change (an evaluation tool)
NARI	National Agricultural Research Institute
NARS	National Agricultural Research System
OECD	Organisation for Economic Co-operation and Development
PM&E	Participatory Monitoring and Evaluation
PPB	Participatory Plant Breeding
SSSA	Seed System Security Assessment
USAID	United States Agency for International Development
WASA	West African Seed Alliance
WASP	West African Seed Program

SUMMARY

This document is part of a series of case studies commissioned by the McKnight Foundation to report on the work of its Collaborative Crop Research Program (CCRP). The aim is to assess the efficiency and effectiveness of the CCRP approach as demonstrated by the accomplishments and contributions of selected CCRP-funded projects. This study on seed systems takes place in this context and is based on “Sustaining Farmer-Managed Seed Initiatives for Sorghum and Pearl Millet in Mali, Niger, and Burkina Faso,” a project that strives, through farmer-managed production of seed, to contribute to sustainable seed supply to small-scale farmers in the three West African countries.

Case study objectives can be summarized as 1) describing the project background and context, 2) describing the project outcomes, 3) assessing specific CCRP contributions, and 4) summarizing lessons learned and recommendations.

To achieve this, a qualitative approach based on semi-structured interviews and focus group discussions, combined with formal questionnaires, was applied. Besides the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), partner organizations included the national agricultural research organizations in Mali (IER), Niger (INRAN), and Burkina Faso (INERA) as well as two farmer organizations each in Mali and Burkina Faso and three in Niger. Altogether, forty-five interviews were conducted with scientists (n=ten), technical staff (n=eleven), representatives of involved farmer organizations (n=thirteen), farmer seed producers (n=118), and other key informants representing, for example, chambers of agriculture, national farmer organizations, private seed enterprises, and seed authorities (n=thirteen). Out of the farmer seed producers, thirty-one (36 percent) were women and eighty-seven (64 percent) were men.

Evaluation criteria were borrowed from two theoretical frameworks: the Seed System Security Assessment (SSSA) and that which is used by the Development Assistance Committee (DAC) of the Organisation for Economic Co-operation and Development (OECD).

The SSSA framework describes three basic functions of seed systems: availability of seed, access to seed, and quality. “Availability” refers to the production side, whereas “access” focuses on the demand side. “Quality” refers to seed utilization, e.g. how useful the offered varieties are in a particular context for different user groups. “Quality” further implies technical quality of the seed offered.

OECD DAC criteria include 1) relevance, 2) effectiveness, 3) efficiency, 4) impact, and 5) sustainability, and are meant to evaluate the broader development impacts and use of funds and resources. Gender and equity issues were addressed in this methodology.

The first part describes the project context as well as the state of scientific knowledge on innovations in seed systems and the political dimensions involved. The importance and main constraints of the sorghum and pearl millet crops for the farming and food systems of the project area are outlined. Advances through research have so far remained limited because variety adoption has occurred at a relatively low level. Also, formal seed systems for making improved varieties available to farmers are practically nonexistent for staple food crops such as sorghum and pearl millet. The project has followed an alternative approach by tying participatory variety development and evaluation to farmer-managed seed production, and by involving farmer organizations as project partners.

This project was found to be highly relevant, as it suggests solutions to prevailing problems of agricultural food and farming systems in the West African region, including stagnating agricultural yields, climate variability and change,

scarcity of resources, population growth, and malnutrition. All organizations involved relate their activities to these same challenges.

The project has successfully contributed to improving seed system security in the area by targeting all three aspects, availability, access, and quality. Core to its success is the development of varieties that are adapted to the local context and produce considerably higher yields under farmers' production conditions while also maintaining other preferred traits. Through the decentralized, participatory variety evaluation trials, farmers have gained contextualized knowledge of these varieties and can make informed decisions on the options available to them. The availability of seed of these varieties has much improved. The number of seed producers has increased from year to year, as has the area used for seed production. The total amount of seed produced by farmer organizations in 2013 was estimated to be sufficient for sowing 16000 ha of sorghum and 11500 ha of pearl millet. By taking a "mini-packet" approach for seed marketing to individual farmers, access to seed has also improved. In addition, there are several other pathways for seed distribution, including through government agencies, NGOs, or private seed enterprises acting as partners of the farmer organizations.

Project activities have proven to be effective with regard to the goals. Compared with other, previous activities targeting seed sector development in the region, they appear to be highly efficient. Impacts were reported by farmers in four different domains: 1) variety adoption and seed systems, 2) productivity, income, and nutrition, 3) knowledge, innovation, and development capacities, and 4) potential negatives.

It can thus be concluded that the project has convincingly demonstrated that farmer-managed seed production is feasible and can, in this particular case, improve variety and adoption and achieve development impacts. The goals were achieved to quite a high degree. There are challenges ahead, however, with regard to project sustainability. Besides necessary improvements in the seed chain itself, concerns exist about reducing risks for farmer organizations and improving the material resource basis for the organizations and the national research institutes. Moreover, the project's sustainability significantly depends on external factors, including decisions at the policy level. These factors should be addressed, which may imply extending research and capacity-building measures beyond the original project focus.

Project funding and support should not be withdrawn at present so as to secure the positive impacts achieved thus far. The project is at an important turning point: moving from a mere experimental research stage, in which methodologies were tested and capacities built, toward broader implementation. The project should support this transition by addressing remaining challenges in the seed chain itself and by developing a broader strategy for seed sector development.

In the seed chain, linkages where farmer organizations directly depend on other actors should be improved. Identified were three critical junctions: 1) provisioning of source seed, 2) seed certification, and 3) coordination of complementary dissemination pathways. Not only knowledge and capacity building but also a material resource base and risk-reducing measures may be necessary to make farmer-managed seed production more sustainable. To address the seed sector as a whole, conducting a policy and a stakeholder analysis is suggested. Such analysis would identify entry points for a science-policy dialogue and establish multi-stakeholder platforms, facilitating the development of shared visions and coordinated action toward the integrated development of more sustainable, equitable, and resilient seed systems in the three countries.

The McKnight Foundation is commissioning a series of case studies based on the work of its Collaborative Crop Research Program (CCRP). The aim is to assess the efficiency and effectiveness of the CCRP approach as shown by the accomplishments and contributions of selected CCRP-funded projects.

By doing so, McKnight seeks to review the impact of the applied research funded under its CCRP program and the extent to which said program has facilitated development, spread of technology, food security, and the improvement of farmers' livelihoods. A focus is on how CCRP's financial and non-financial support has benefited the projects' and organizations' research and development capacity over time, particularly the R&D sustained capacity among local institutions and approaches. Furthermore, the case studies should result in recommendations for future sustainability, farmer involvement, and skill strengthening.

This study takes place in this context and is based on the CCRP-funded project "Sustaining Farmer-Managed Seed Initiatives for Sorghum and Pearl Millet in Mali, Niger, and Burkina Faso." A major focus is on strengthening the capacity of farmer groups for good quality seed production, monitoring seed quality, bookkeeping, seed marketing and prediction of demand, data documentation, and communication of results. Women were to be explicitly involved in the project's key activities. The project also made specific efforts to develop a better understanding of the impacts achieved, especially in terms of dynamics in seed networks and farmers' access to seed.

In the process leading to commissioning this case study, independent consultant, Robert Tripp summarized the results of a brief consultancy, narrowing down and substantiating the focus of a case study on the topic "seed" (Tripp, 2013). He emphasized that the term refers not simply to a physical commodity but to an exceptionally large number of activities implicit in it, including those related to plant breeding, extension and training, analytical activities (e.g. analysis of seed systems), seed production, relevant policies, and technical outcomes, such as variety adoption. Tripp cited the usefulness of focusing a case study on a subset of seed-related activities rather than attempting to simultaneously address the many areas that can be considered seed-related. Moreover, a case study on seed systems should focus more on organizational or institutional progress versus the mere production or utilization of a commodity and, thus, on the change in capacities for providing adequate seed in a sustainable manner among companies, farmer organizations, and government entities.

This case study takes up these recommendations by focusing on developments in the seed system, particularly on improvements concerning *availability* of seed, farmers' *access* to seed, and seed *quality*. Excluded are the breeding part or the spread of particular varieties. However, the availability of varieties that are attractive to farmers is an important prerequisite for seed system development, and the diversity and relevance of the varieties on offer touch the quality aspects of a seed system. The breeding and seed system are thus regarded as one, with the focus on activities relating to seed production, marketing, and distribution.

Additionally, we look into the project's development impacts and the specific contributions of the CCRP, particularly the capacity-building and networking activities that formed part of the project. To some minor extent we consider the broader political context in which the project has been implemented, exploring its relevance to and coherence with national policies and any external supporting or hindering factors.

Case study preparations began in November 2013 with the establishment of first contacts and meetings. These led to the creation of a team, formal contracts, and an agreed-upon methodology. Therein arose three major activities: 1) collecting written documents for review with the help of project partners, 2) communication via formal questionnaires and e-mail for basic and quantitative information, and 3) an evaluation mission, which was con-

ducted in February 2014. Some background interviews and meetings, either in-person or via Skype, complemented the information and helped focus the study.

In February 2014, the evaluation team of Gottfried Horneber and Marthe Diarra visited scientists, farmer organizations, representatives of government entities, private enterprises, and NGOs in the countries where project activities were implemented: Mali, Niger, and Burkina Faso. By meeting project partners in all three countries, the evaluators considered the idea of a regional Community of Practice (CoP) relating to seed and variety development in West Africa, deciding that such would result in less time being spent with each project partner and also less possibility to explore the surrounding context of each individual initiative.

2 OBJECTIVES

McKnight's interest focuses on the impact relating to the more technical outcomes of the applied research as well as its broader development impact. This case study seeks to understand how the funding and support given under the CCRP has specifically contributed to capacity building among the involved institutions and what lessons can be learned for the program's future strategic orientation.

The objectives of this case study can thus be summarized as being fourfold:

1. **Project background and context** Describe issues associated with the project and the regional context in which the project has been operating, including those relating to seed systems and the pearl millet and sorghum crops
2. **Outcomes** Outline the project's setup and strategy, its accomplishments, major landmarks and reorientations in relation to the goals pursued, and the capacity building of organizations and institutions involved
3. **CCRP contributions** Document grantee perceptions relating to key elements of the CCRP approach, relations with other projects and funding, impact on research and development capacity, and adaptive learning capacity of institutions involved
4. **Lessons learned and recommendations** Share lessons from the project's experiences and areas for improvement in CCRP support, including implications for the future CCRP strategy for strengthening small-scale, farmer-focused seed systems in West Africa

3 METHODS

This section provides information on the theoretical frameworks on which assessments are based, as well as the methodologies for selecting sites and interview partners, obtaining and structuring information in the field and via questionnaires, and evaluating results.

3.1 THEORETICAL FRAMEWORKS FOR THE ASSESSMENT

In accordance with the above objectives, assessment was based on two widely accepted and applied theoretical frameworks: the Seed System Security Assessment (SSSA) and the criteria used by the Organisation for Economic Co-operation and Development (OECD) for assessing development impact. Combining these approaches answers McKnight's stated interest in assessing both the impact relating to improvements in seed systems and the development impact. Moreover, several cross-cutting issues were addressed, including gender and equity considerations.

SEED SYSTEM SECURITY ASSESSMENT (SSSA)

SSSA has been developed and used by several groups of researchers and development practitioners since the 1990s. Its original focus was on better targeting of seed aid interventions in the context of disaster relief (Remington et al., 2002; Sperling, 2008). The basic idea of SSSA is to understand how seed systems function in normal situations and to assess their strengths and weaknesses. Based on this assessment, any interventions in crisis or disaster situations can be designed in a way that builds on the strengths and compensates for weaknesses. The SSSA concept is strongly related to food security frameworks commonly used by aid organizations (e.g. LIFT, 2011). Therefore, it fits into strategies that aim to improve food and livelihood security.

SSSA has attracted interest from other researchers because knowing the strengths and weaknesses of a seed system can also help identify strategic entry points for other interventions, and not only those in disaster situations. The assessment might question how existing seed systems can be strengthened and developed further, and how new institutions can be built up in situations where traditional seed systems have become weak.

The SSSA concept looks at seed system security under three general aspects:

- availability of seed
- access to seed
- quality of seed

Availability describes the *production* part: whether seed is being produced, stored, and sold in adequate quantity and at the right time.

Access draws attention to the *demand* side: Do (all) people have the means to buy or barter for seed, and is the seed sold and distributed in a way that is physically and economically accessible to all?

Quality emphasizes the *utilization* aspect: whether and to what extent the seed meets people's multiple needs and requirements. Quality here entails more than just technical seed quality (e.g. germination capacity, seed health, purity); it further includes varietal properties—whether varieties are adapted to the existing farming systems and agroecological conditions, meet the requirements of market partners, or fulfill consumer needs, such as processing quality and nutritional value. Moreover, the functional diversity of offered varieties could be regarded as part of a seed system's quality dimension.

This case study didn't actually conduct a SSSA but used the concept and underlying criteria to structure and ask for information. Looking at seed systems from these aspects can help assess whether and how applied innovations have contributed to overcoming existing seed system weaknesses identified in the baseline or diagnostic studies.

OECD CRITERIA FOR EVALUATING DEVELOPMENT ASSISTANCE

The OECD is a forum where the governments of thirty-four states work together to address the economic, social, and environmental challenges of globalization. To achieve its aims, the OECD has a number of specialized committees, one of which is the Development Assistance Committee (DAC). DAC members periodically review the nature of their contributions to aid programs, consulting each other on relevant aspects of their development assistance policies (OECD, 2013a). The OECD DAC has since the 1990s formulated principles and quality standards for evaluating development assistance; periodic reviews look at how evaluation systems are evolving and examine current issues (OECD, 1991; OECD 1998; OECD 2000).

The OECD DAC suggests considering the following criteria for evaluation of development assistance (OECD, 2013b):

- **Relevance** The extent to which the aid activity is suited to the priorities and policies of the target group, recipient, and donor
- **Effectiveness** The extent to which an aid activity attains its objectives
- **Efficiency** Measuring the outputs—qualitative and quantitative—in relation to the inputs. “Efficiency,” after all, is an economic term signifying that the aid uses the least costly resources to achieve the desired results. This generally requires comparing alternative approaches for achieving the same outputs, to see whether the most efficient process has been adopted.
- **Impact** The positive and negative changes produced by a development intervention, directly or indirectly, intended or unintended. This involves the main impacts and effects resulting from the activity on the local social, economic, environmental, and other development indicators.
- **Sustainability** Concerned with measuring whether the benefits of an activity are likely to continue after donor funding has been withdrawn. Projects need to be sustainable environmentally and socially as well as economically.

The OECD DAC criteria thus represent a framework for evaluation of a project’s broader development impact beyond its technical outcomes. As noted above for the SSSA, the OECD DAC criteria were used for structuring evaluation and focusing questions.

ADDITIONAL CRITERIA

In addition to the above criteria, we considered gender and equity issues in our methodology, “gender” being referred to in the broader context of intersectionality, which means being generally aware that project activities or outcomes can benefit or affect people differently, e.g. depending on age, gender, or ethnicity.

Involving both women and men in key project activities was a goal set by the project itself but, apart from this, is a widely accepted quality criterion for project evaluations. Furthermore, gender is a sensitive issue for activities relating to seed.

With Gottfried Horneber and Marthe Diarra forming the evaluation team, both genders were represented on the team and both had specific expertise and experience with the topic. No separate groups were formed for women and men during the fieldwork, but care was taken to allow the women, who were in most cases outnumbered by male participants, to express their views. In one case a special interview was organized with members of a women seed producer group. Gender-specific aspects of seed system development were part of the team’s joint reflections and are presented in the results section where relevant.

3.2 SELECTION OF SITES AND INTERVIEW PARTNERS

The selection of sites visited depended on where the project partner organizations were based and had enrolled their field activities. These organizations included the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and the National Agricultural Research Institutes (NARI), farmer organizations, and seed producer groups. Additionally, some key informants—representatives of Ministries of Agriculture, Chambers of Agriculture, National Seed Services, commercial seed enterprises, and NGOs—were contacted or visited.

Project partners and their representatives in Mali, Niger, and Burkina Faso were identified with the help of contact people identified by ICRISAT and the McKnight Foundation. Furthermore, a contact list circulated via e-mail gave more people the chance to add key informants and organizations. For the selection of participants the evaluation

team depended on the technical staff of farmer organizations and ICRISAT, as they had invited participants to the meetings. The farmer participants were 1) representatives of the farmer organizations, and 2) members directly involved in project activities, e.g. farmer seed producers. Given that the focus was on people who had actively participated in project activities, neither an inquiry among all members of these farmer organizations nor a representative sample of all villagers were organized.

The evaluation team spent four to five days in each country. Besides the research organizations, two farmer organizations per country were visited in Burkina Faso and Mali, including visits to seed producer groups and facilities for seed storage, processing, and sales. In Niger, only one farmer organization and field location was visited. In addition, a meeting with representatives of two other farmer organizations was held at Niamey because of security and time considerations. Altogether, the evaluation team conducted forty-five interviews. Interview partners were scientists (n=ten), technical staff (n=eleven), representatives of farmer organizations involved in project activities (n=thirteen), farmer seed producers (n=118), and other key informants, including representatives of Chambers of Agriculture, national farmer organizations, private seed enterprises, and seed authorities (n=thirteen). Out of the farmer seed producers, thirty-one were women (36 percent) and eighty-seven were men (64 percent).

As in many other parts of the world, women are generally underrepresented in institutional leadership positions in West Africa. Where interview partners were selected based on their official assignment (e.g. researcher responsible for sorghum breeding, or president of a farmer organization), only a few women were among the interview partners. Women are also underrepresented in seed-producing activities. Tables 1a and 1b list the research and farmer organizations that contributed to the evaluation. Detailed information regarding individuals and organizations visited is given in Annex A.

Even though covering a range of agroecological conditions was not a focus in site and interview partner selection, the farmer organizations work in different regions and, accordingly, focus on producing either sorghum or pearl millet seed. Therefore, the main crop and average annual rainfall data of the location were included in Table 1b (see next page).

Less fruitful was the attempt to include some critical voices of people who and organizations that were acting in the field but not involved as project partners. E-mail inquiries (e.g. directed to several “La via campesina” member organizations in Mali, Niger and Burkina Faso) went unanswered, and some representatives of organizations visited did not seem well enough informed about the project to provide detailed feedback.

3.3 FIELD METHODS

The evaluation team relied on semi-structured interviews for the fieldwork. Separate versions—for scientific and local partners, respectively—of interview guides were prepared beforehand in order to make sure that the discussions covered all of the important topics. Evaluation inquiries were formulated as open questions, e.g. how participants had benefited from project activities and training events, or what gains and losses were achieved.

Also used was the Most Significant Change (MSC) technique, which is a Participatory Monitoring and Evaluation (PM&E) tool that does not rely on predefined indicators. It is most useful in cases where project outcomes vary widely between stakeholders or where no agreement exists on what outcomes or impacts are important.

Essentially, the process involves collecting individual participants’ stories on impacts they experienced, followed by joint reflection in the group or at higher organizational levels or both. Rick Davies, who first described and applied the method, called it an “evolutionary approach to facilitating organizational learning” (Davies, 1998). MSC can thus be used to create hypotheses about changes that took place and also to identify and understand the underlying

ing criteria, values, and rationales. It is further useful to capture unexpected or negative change (Davies & Dart, 2005).

The original plan was to use supportive visual tools but this turned out to be difficult because a large number of focused questions and topics needed to be addressed rather than initiating an open dialogue. In practice, these tools were not implemented.

Table 1a: Research organizations contributing to the evaluation in Mali, Niger, and Burkina Faso

Country	Location	Scale of activities	Name of organization
Mali	Bamako	International	International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
Mali	Bamako	National	Institut d'Economie Rurale du Mali (IER)
Burkina Faso	Ouagadougou	National	Institut de l'Environnement et de Recherche Agricole (INERA)
Niger	Niamey	International	International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)
Niger	Niamey	National	Institut National de Recherche Agronomique du Niger (INRAN)

Table 1b: Farmer organizations contributing to the evaluation in Mali, Niger, and Burkina Faso

Country	Location (region)	Ø Annual rainfall [mm]	Focus crop	Name of organization
Mali	Mandé/Siby (Koulikoro)	750-1000	Sorghum	Association des Organisations Professionnelles Paysannes/ Coopérative des Producteurs Semenciers du Mandé (AOPP/COOPROSEM)
Mali	Dioïla (Koulikoro)	750-1000	Sorghum	Union Locale de Producteurs Céréales (ULPC)
Burkina Faso	Kaya (Sanmatenga)	500-650	Sorghum	Association Minim Sông Pânga (AMSP)
Burkina Faso	Dédougou (Boucle du Mouhoun)	800-950	Sorghum	Union Groupements Commercialisation des Produits Agricoles de la Boucle du Mouhoun (UGCPA/BM)
Niger	Falwel (Dosso)	385-490	Pearl millet	Union des producteurs « MADDA-BEN » /Fédération des Union de Groupements Paysans du Niger Mooriben (MADDA-BEN/FUGPN Mooriben)
Niger	Téra (Tillabéri)	310	Pearl millet	Union de groupements paysans « HAREYBEN» Téra/ Fédération des Union de Groupements Paysans du Niger Mooriben (HAREYBEN/FUGPN Mooriben)
Niger	Serkinhoussa (Maradi)	410	Pearl millet	Fédération des Unions de Producteurs de Maradi (FUMA- Gaskiya)

SOURCES: CCRP project report “Farmer-participatory improvement of sorghum and pearl millet genetic resources for increased adaptation to diverse production environments in West Africa,” Report March 2008 – February 2009, plus questionnaires.

3.4 QUESTIONNAIRES

Different questionnaires were developed for local organizations and for scientific partners. Both were sent out shortly before the field visits. The questionnaires helped reduce the number of topics to be explored during the visits and included some quantitative information, e.g. on the development of seed production and sales.

The questionnaires were handled independently and by another person, making this a form of triangulation to complement the information from the field. They also opened up the possibility of starting an e-mail correspondence and asking for documents or clarifications.

It was expected that the flow of information via this channel would be limited. All of the farmer organizations returned completed questionnaires while only a few were submitted from researchers.

3.5 EVALUATION OF RESULTS

Field study findings were documented by taking notes and discussing the results and preliminary findings within the evaluation team. The questionnaires were designed in a way that the questions related directly to the SSSA framework and the OECD DAC criteria, allowing the information to be summarized under these topics. For Skype interviews, notes were taken in a structured form using the OECD DAC criteria as headings and complemented with further predefined questions, e.g. relating to breeding techniques or the legislative framework. Quantitative information such as the number of producers, varieties, and amount of seed produced were evaluated graphically to identify trends.

In the interest of building trust, interview partners were assured that the information and, particularly, the personal statements, opinions, and recommendations would be treated confidentially. Hence, information appears anonymously in this report in an aggregated form.

4 RESULTS

The study results are summarized under five broad topics: (4.1) general project context and background, (4.2) project design, (4.3) project outcomes with regard to seed system development, (4.4) development impact of the project, and (4.5) specific contributions of the CCRP.

4.1 PROJECT CONTEXT

This section summarizes how informal and formal seed system development has emerged on the agendas of agricultural scientists and development practitioners, not least in connection with plant breeding projects. Seed system development is a question of technical and institutional development but also a political issue that forms part of a general debate on the future orientation of agriculture. The third subsection introduces the concept of Integrated Seed System Development, which aims at balancing the multiple functions and goals seed systems have to fulfill. The final brief describes sorghum and pearl millet production and seed systems in West Africa.

INFORMAL AND FORMAL SEED SYSTEMS

Since the 1990s, the functioning and development of traditional seed systems has emerged on the agendas of agricultural scientists and development practitioners alike. Initial studies highlighted the general importance of traditional (informal) seed systems for sustainable seed supply of the world's vast majority of food crops. It was estimated that informal sources of seed supply, including farm-saved seed, seed from neighbors and relatives, or from local markets and traders, accounted for 80 to 90 percent of the total seed supply worldwide (Almekinders et al., 1994). A recent assessment that included data from six African countries showed that farmers even today obtained as much as 90 percent of their seed from informal sources (Sperling & McGuire, 2013; cited in Sperling et al. 2013). These findings underline the quantitative importance of informal seed systems for food and farming systems worldwide.

Some basic insights into the functioning and structure of these traditional, informal seed systems stem from people working in emergency aid who are concerned about the effectiveness of seed aid and its effects on seed system security in the longer term (Remington et al., 2002; Sperling & Cooper, 2003). Similar to the situation concerning food, seed of local varieties is nearly always available with some farmers, even in disaster situations, but other farmers lack access to it because of deficient purchasing power or social marginalization. These findings thus highlight the ways that seed is being managed and disseminated in local, informal systems, and the systems' related strengths and weaknesses, including equity issues.

Such issues were also addressed in basic research on social and anthropological aspects of traditional seed systems: distribution pathways, management, terms and conditions of exchange, and the way seed systems are embedded in social systems (Longley, 2000; Badstue et al., 2002; Badstue 2007; Christinck, 2002; Delêtre et al., 2011). Some of these studies further focus on the relation between traditional seed transactions and genetic diversity of crops (Christinck, 2002; vom Brocke et al., 2003; Delêtre et al., 2011; see also Jarvis et al., 2004).

Important findings that can be summarized from these studies are that most seed transactions in traditional seed systems, depending on the social relationship between the individuals, take the form of gifts or are based on non-monetary exchange. Most transactions take place in relative proximity: within a village or clusters of neighboring villages. There are, however, opportunities for exchange over larger distances, mostly on the occasion of festivities, such as marriages, religious festivals, markets, and fairs. Some individuals or groups play a key role for seed exchange and diffusion in and among villages.

The importance of women in traditional seed systems has often been emphasized (see, for example, Tapia & de la Torre, 1998). In many countries, women play a key role in selecting, storing, and distributing seed of important food crops. Changes in seed systems tend to affect gender roles, redistribute responsibilities for and access to resources, and may affect food and nutrition security (Howard, 2003; Pionetti, 2005; Momsen et al., 2013). The informal seed system is particularly important for women farmers as a source of seed, given its advantages with regard to availability in the village neighborhood and access. In the informal seed system, payments can be made flexibly, in cash or kind, or based on other forms of reciprocity.

Other researchers focused more on innovation and change in seed systems, particularly with regard to their capacity to provide access to newly developed varieties from breeding programs (Ndjeunga, 2002; Siart, 2008) or their adaptive capacity to new challenges, e.g. climate change (Bellon et al., 2011). Whereas the informal sector regularly provides seed of traditional varieties, diffusion of new varieties through informal channels is generally slow. Depending on flowering dates, outcrossing rate, and varietal structure, challenges may arise for maintaining the varietal identity under on-farm conditions. This is even more the case for hybrid varieties. Without special

measures and organizational structures, breeding progress achievements can be lost within a few years. The question thus becomes how can seed of newly bred varieties be diffused efficiently to farmers in situations where formal seed markets are only weakly developed.

Basic work on the conditions for the emergence of formal seed sectors in developing countries has been done by Tripp (2001; 2003; 2006). He argues for shifting seed production and dissemination of formal variety seed to the commercial sector rather than investing in public seed enterprises, and also emphasizes the complementary roles played by farmers and public institutions in the emergence of a commercial seed market.

According to Tripp (2003), a commercial seed market will develop only when it can offer farmers a clear advantage over on-farm seed saving. Such advantage could take several forms, including convenience, access to superior germplasm, and seed quality. Furthermore, demand can be stimulated if markets where farmers sell their produce pay premium prices for particular varieties. He states that “On the one hand, farmers are often willing to pay a premium for seed of a new variety, but unless that seed is difficult to save, or there is a fairly constant offering of new varieties, it is not likely that a seed enterprise will be able to base its business solely on the provision of new varieties.” Other reasons for farmers to use seed from off-farm sources include poverty (no possibility to keep own seed) or quality problems, but both lead to occasional seed purchase rather than represent a stable source of demand. Also of concern: Farmers may more easily opt for buying seed from commercial sources if seed requirements are low or if additional labor requirements for saving own seed are high, as is the case for some vegetable or forage crops (Tripp, 2003; Bentley et al., 2011).

Traditional seed production is embedded in the normal routine of farming, with relatively few specialized management decisions and working operations being used to separating seed from the general harvest. This differs for commercial seed production, which entails a chain of highly specialized activities: plant breeding and variety evaluation, registration, source seed production, seed multiplication, quality control, conditioning and storage, and marketing and distribution. In addition to the considerable investment and capacity building involved in all of these steps, some sort of regulatory framework exists in nearly all countries.

However, especially if the public regulatory agencies are weak and lack resources, the insistence on formal certification may be a serious disincentive to emerging seed production initiatives. Tripp (2003) therefore calls for a more flexible quality control system based on agreed-upon standards and spot checks, and suggests that regulatory frameworks should strive to support rather than restrict emerging seed enterprises.

In many African countries, formal seed markets hardly exist for staple food crops, with hybrid maize (besides cotton) being an important exception. Ndjeunga (2002) studied the pearl millet seed market in Niger, concluding that prior investments for establishing a formal seed market had largely failed. Less than 2 percent of the pearl millet seed used by farmers stemmed from the formal sector at the time of the study, and subsidized seed prices represented less than one-third of the average cost of seed production. He therefore argues for strengthening local (informal) seed markets, particularly during drought periods, and for encouraging individual seed producers or groups of farmers in each community to become entrepreneurs tasked with the multiplication and distribution of new pearl millet varieties. A similar outlook is also proposed by Kaboré et al. (2010) for Burkina Faso.

However, Bentley et al. (2011) state that it may even be more difficult for small-scale seed producer groups than for private seed companies to collaborate with the public sector for source seed supply and certification services. Inadequate production of source seed is a major constraint in sub-Saharan Africa. Furthermore, producing good quality seed may be a key competence of many farmers, whereas this is not necessarily the case for running successful seed businesses. Farmer seed enterprises frequently lack access to adequate equipment, networks, and credit, and very often the true production cost exceeds the sale price of the seed.

In conclusion, the emergence of commercial seed markets, with or without farmer producer groups playing an important role, is a long-term task. Its success or failure depends on the availability of varieties that have advantages for farmers, the capacity of seed producers to deliver seed of high and reliable quality, the development of markets and conditions for agriculture in general, and the degree of trust and accountability that exists between market partners as well as between them and the government institutions that set the regulatory framework.

BREEDING AND SEED SYSTEMS DEVELOP IN A FORCE FIELD OF DIVERGING AND SHARED INTERESTS

Breeding and seed systems are multi-actor systems, the relations between which are characterized by shared as well as diverging interests and by power imbalances. Table 2 lists some interests of various actors in seed systems.

Table 2: Shared and diverging interests of stakeholders relating to emerging commercial seed markets

Stakeholder	Interests
Government	<ul style="list-style-type: none"> • Set rules to ensure food security and an adequate level and stability of agricultural production • Implement international agreements • Economic development of the agricultural sector
Plant breeders	<ul style="list-style-type: none"> • Produce varieties for which demand exists among farmers • Regularly feed new varieties into seed market • Get adequate funding for scientific and practical work relating to variety development and fulfill donor/company expectations
Seed producers	<ul style="list-style-type: none"> • Produce and sell a stable or growing quantity of seed of varieties for which demand exists • Transparency of rules and regulations to which they must comply
Seed traders	<ul style="list-style-type: none"> • Sell a set of known varieties for which demand exists over many years • Low risk and transaction cost
Farmers	<ul style="list-style-type: none"> • Additional option to get seed in case of need (depending on own stock, weather conditions, etc.) • Sufficient quality of seed available in the market • Easy access to a set of improved varieties with various distinct/complementary characteristics • Affordable seed price • Profit from breeding progress to develop their farm and improve income
Food processors	<ul style="list-style-type: none"> • Profit from breeding process to optimize production process and increase value • Standardize variety portfolio of producers to facilitate production process
Consumers	<ul style="list-style-type: none"> • Taste, storage, and cooking quality of products • Nutritional and health aspects • Affordable food price

Besides the actors' shared interest in having available varieties of seed demanded by farmers and that fulfill consumer needs, a number of diverging interests exist. Plant breeders, farmers, and consumers share an interest in establishing a continuous flow of material (seed) and information so that the most suitable and desired varieties are continuously being developed and produced. Seed producer, food processor, and trader interest is generally to limit the number of varieties used by farmers so that transaction costs and risk can be reduced. Regularly replacing well-established varieties with new, improved ones may appear as an additional cost factor, if not justified by additional benefits.

At the same time, farmers and consumers share an interest in having at their disposal a greater number of varieties for various purposes and needs. Moreover, it is generally not in a farmer's interest to exclusively and regularly buy seed from the formal seed market. If seed of preferred varieties can be reproduced on-farm without quality loss, it is usually much less costly than seed from a formal seed production chain. Farmers thus tend to see the formal seed market as an additional option that complements their own informal system of seed production and farmer-to-farmer distribution, and one they can use in case of need. For example, it is often reported that farmers buy seed immediately before sowing and choose the variety they sow according to the onset of rains and other factors.

Seed producers and traders, in contrast, are interested in selling seed to farmers on a regular basis instead of trying to meet a highly fluctuating demand. They often concentrate on varieties that cannot be reproduced easily on-farm (e.g. hybrid varieties) and for which, subsequently, more stable demand exists. Restricting the legal space for the informal seed market may appear as an option to shift demand and power toward the formal system in the longer term.

Lastly, plant breeders' interest is driven by their institutions and source of funding. In commercial breeding and seed enterprises, plant breeders are usually expected to serve the commercial interest of the company, e.g. for profitably marketing seed and other agricultural inputs. In contrast, plant breeders working in public institutions have to focus their work on public goods, including, for example, food and nutrition security, or farming system resilience (see further implications for seed system development below).

Thus, to adequately design strategies and policies that support sustainable seed system development, it is necessary to acknowledge that breeding and seed systems develop in a force field of diverging as well as shared interests and power imbalances.

THE FUTURE DEVELOPMENT OF AGRICULTURE AND SEED SYSTEMS: A MATTER OF POLITICAL DEBATE

The growing commoditization of seed and development of commercial seed markets in Africa and worldwide is subject to controversial political debate. As Bentley et al. (2011) state: "The formal seed system is actually a marriage between the government and the private sector..." In Africa and elsewhere, the needs, contributions, and rights of farmers and local communities have seldom been considered in developing a political vision and designing the regulatory frameworks for seed commercialization.

Civil society movements criticize that agricultural policies, particularly those concerning the seed sector, are often driven by the interests of commercial enterprises (Daño, 2007; Herre, 2008; Thompson, 2012; Clausing, 2013). However, states are first and foremost obliged to protect and promote their citizens' rights, including the Right to Food, to comply with obligations deriving from international agreements and to set a regulatory framework that facilitates innovation, economic growth, and sustainable development.

In his report to the United Nations General Assembly, Olivier de Schutter, the UN Special Rapporteur on the Right to Food, highlighted the importance of informal seed systems for food security of vulnerable groups. He stressed that informal seed systems will continue to be marginalized if states do not take targeted measures to strengthen them. A focus on protection of intellectual property rights of plant breeders and commercial enterprises can impede, rather than enhance, innovation in variety development and seed provision (de Schutter, 2009). The conservation and sustainable utilization of agrobiodiversity falls under the commitments made by countries in signing international agreements, such as the Convention on Biological Diversity (CBD) or the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA). Articles 6 and 9 of the ITPGRFA relate to appropriate measures for promoting the sustainable use of genetic diversity. The participation of farmers is explicitly stated in Article 6, with the aim of developing varieties that are adapted to the social, economic, and ecological circumstances faced by farmers, particularly in the marginal areas of developing countries. It also calls for the creation of a broader genetic base for crop plants and the promotion of local species and varieties, particularly underutilized crops. It further states that breeding strategies will possibly have to be altered and the seed legislation revised to facilitate these measures. Article 9 refers to Farmers' Rights, including these four aspects: 1) the right to save, use, exchange, and sell farm-saved seed, 2) the protection of traditional knowledge, 3) the right to be involved in decision-making pertaining to the use of genetic diversity, and 4) the right to share in any benefits arising from the use of the genetic resources.

However, these rights remain in part only vaguely defined in the treaty, mainly with regard to the first aspect, which touches on the interests of the commercial seed industry (Andersen, 2013a). She states: "Despite the lack of precision, the general line of thought is clear: It is important that farmers be granted rights in this area although the individual countries are free to define the legal space they deem sufficient for farmers regarding their rights to save, use, exchange, and sell farm-saved seed." In the recent decades, the legal space of farmers in this direction has been steadily more restricted in many countries, with Norway and India being important exceptions (Andersen, 2013b; Winge et al., 2013).

The political debate around seed policies can also be seen in the wider context of an existing controversy on the direction of agricultural and food system development in general and the policies' importance for strengthening the economies of developing countries. Opening agricultural markets for more international competition tends to force actors toward more efficient production methods to increase specialization and scale of production units. According to Herre (2008), putting a strong focus on productivity gains in agriculture and employment in political strategies for agricultural development cannot be the answer for hunger and poverty reduction; this approach ignores the social and ecological costs involved and continues to focus on increasing food availability rather than clearly targeting the question of how access to adequate food can be secured in a sustainable manner for vulnerable people.

Wider deployment of agricultural biodiversity is essential for sustainable delivery of a secure food supply that fulfills human dietary needs and can increase the productivity and resilience of farming systems in a variety of growing conditions (FAO/PAR, 2011; Frison et al., 2011). However, agrobiodiversity does not seem to be actively addressed in any of the current international initiatives proposed for agricultural development in Africa, including the Comprehensive Africa Agriculture Development Programme (CAADP) and the Alliance for a Green Revolution in Africa (AGRA).

The International Assessment of Agricultural Knowledge, Science and Technology for Development (IAASTD) attributes a crucial role to agroecology in shaping sustainable agricultural development (IAASTD, 2009). The concept of sustainable intensification that has recently been promoted by the Food and Agriculture Organization of the United Nations (FAO) and other international organizations, however, is not a synonym for an agroecological ap-

proach, as it is quite narrowly focused on increasing food production. In order to contribute to sustainable development of food and farming systems, it needs to be treated simultaneously with other related policy issues, including, for example, preserving biodiversity, animal welfare, human nutrition, and promoting rural economies (Garnett et al., 2013). Governments as well as international organizations will have to navigate among these potentially conflicting issues and goals and develop more integrated, cross-sectoral policies to facilitate sustainable development.

A study by the Deutsche Bank research department some years ago differentiates between technology-centered and system-based approaches to developing agriculture and food systems. According to the study, both approaches have different impacts on societies. The system-oriented approach is better suited to counteracting inequality and reducing poverty, as it creates fewer dependencies and spreads power instead of concentrating it (Deutsche Bank Research, 2009). It can be expected that both approaches will be promoted simultaneously by different actors and interest groups.

INTEGRATED SEED SECTOR DEVELOPMENT

Since the 1990s it has been proposed to better integrate informal and formal seed systems and improve the linkages between them in order to better serve farmers' needs and improve seed system resilience (Almekinders et al., 1994; GTZ, 2001; McGuire & Sperling, 2013). Formal and informal seed systems have different, but in parts complementary, characteristics (see Table 3).

Table 3: Complementarities of formal and informal seed systems for various criteria

Criterion	Formal seed systems	Informal seed systems
Outreach (scale)	limited	wide
Varieties offered	high-yielding varieties of some major crops	mainly local varieties of a range of locally important crops ⁽¹⁾
Diversity of crops and varieties offered	low	high
Technical seed quality	usually high and standardized	usually high, but variable
Seed price	high	low
Quality and relevance of information provided ⁽²⁾	limited	high

NOTES: (1) some varieties of the formal breeding sector may also circulate through informal seed systems; (2) from a farmer's perspective

Informal seed systems provide extensive networks that reach nearly every farmer—a fact that is often undervalued—whereas formal seed systems tend to have a limited outreach in many developing countries. The formal seed system concentrates on widely adapted varieties of a few major crops, while the informal sector offers local varieties of all crops grown in that locality. These varieties are adapted to the specific conditions of that location and may be complemented with some varieties originally derived from the formal breeding sector. The diversity of crops and varieties tends to be higher in the informal seed sector. For example, seed of neglected crops may not be available at all via formal distribution channels.

The technical quality of seed sold tends to be high in both systems for the majority of crops. It may vary in informal seed systems, depending on season and storage methods. Specific problems may exist with seed-borne diseases or viral infections in certain species or some vegetatively propagated crops. However, quality problems also occasionally creep into formal seed systems and, when they do, it is likely on a large scale. As a result, there is no simplistic correspondence between formal sector seed and high quality nor informal sector seed and low quality. Seed producers, traders, and customers in informal systems rely on personal trust rather than official labels. Producers and traders in informal systems may take particular action to secure seed quality, e.g. by sourcing seed from particular fields and farmers or by separating seed and food grain. Seed price is usually much lower in informal seed systems, as the necessary level of investment in labor, machinery, storage facilities, packaging, transport, distribution, etc., is much lower (Bentley et al., 2011). Lastly, the information available when buying seed is usually perceived as more reliable and relevant from a farmer's perspective if seed is purchased from neighbors or relatives compared with that from seed sellers in the market. Informal seed systems thus have many advantages from the farmers' viewpoint.

For the formal seed sector, several options exist for linking up with informal seed systems and creating new, complementary distribution pathways. Well known strategic activities to improve availability and access to improved seed for small-scale farmers are: 1) increase the number and proximity of seed outlets, 2) reduce the size of seed packages, and 3) facilitate access for farmers and traders to information about relevant varieties (Sperling et al., 2013). Small seed packages, in particular, facilitate experimentation and can be obtained at a price affordable to most farmers. Small seed packages can easily be sold in local markets and at general stores in villages. Mobile shops or specific outlets within the reach of marginalized groups are further options for multi-channel distribution.

Variety registration and seed legislation

*A major obstacle for the registration of crop varieties from the informal sector are the so-called "DUS criteria" defined by the International Union for the Protection of New Varieties of Plants (UPOV). These criteria have been defined as **distinctness, uniformity, and stability** (UPOV, 2002). However, many landraces or landrace-based populations lack uniformity, which is in fact understood as an important aspect of adaptation to variable environmental conditions (see, for example, Haussmann et al., 2012).*

Farmer varieties may fail to meet these criteria. Moreover, in many countries, varieties need to be tested in official, multi-locational trials before qualifying for registration. The trial design usually does not reflect the conditions and needs of resource-poor farmers, rendering the results of little relevance to them.

Variety registration as well as seed certification rules and fees can thus result in barriers for potential interaction between the formal and informal seed systems (Louwaars & De Boef, 2012).

Easy availability and access to seed enable farmers to quickly adapt their sowing patterns to variable climatic conditions or in case of crop failure. Offering a set of varieties that have been tested and characterized locally for various and specific conditions helps farmers increase resilience of their farming systems under varying stress conditions (McGuire & Sperling, 2013). Physical availability of any seed is only as good as the information that guides its use. That is why short-term information (e.g. via radio or SMS on newly available varieties and seed) could be combined with a long-term approach to enhance context-specific and strategic learning and experimentation, e.g. by establishing networks of participatory variety evaluation trials. Not only farmers but also local traders should have up-to-date and local, context-related knowledge on varieties and their properties. However, concrete steps toward scaling up such approaches and institutionalizing them have remained largely unexplored (McGuire & Sperling, 2013).

At the same time, it tends to be more difficult for farmers to create linkages between their informal seed systems and formal institutions and distribution channels than vice versa. Perhaps this is because the structure of the formal seed system and its organization, through existing policy and regulatory frameworks, widely ignore the relevance and value of the informal system and its products. The formal entities can even lead to the dismantling of such traditional systems. In particular, the variety registration rules and seed legislation too often focus only on the commercial breeding and seed sector, ignoring that other, complementary structures are also needed. Therefore, an integrated approach to seed system development has been proposed for creating coherence between policies, programs, and practices relating to the provision of seed, and to balance public and private sector involvement (Louwaars & De Boef, 2012).

Publicly funded plant breeding in developing countries needs to be development oriented: It should serve public goods, whereas private breeding is market oriented. The structural adjustments of the 1980s and 1990s, however, led to a withdrawal of the public sector from seed production and distribution activities. As a result, the private breeding and seed sector took that part of the seed market that is commercially interesting, whereas weaknesses exist in seed delivery of varieties from the public breeding sector: “Remaining and often weakened public breeding programs that are responsible for other major food (non-maize) crops are unable to disseminate their varieties to farmers upon release. The seed value chain for major food crops (other cereals, pulses, and oil crops) lacks the seed production component... In many cases, NGOs began operating in this vacuum; in other cases, research centers chose to work directly with farmers in disseminating their varieties. Emerging small-scale seed enterprises, or local seed businesses, aim to fill this gap in the seed value chain for many food crops...” (Louwaars & De Boef, 2012)

The researchers further highlight that, even though the basic components are essentially the same—breeding, seed production, and marketing—development oriented and commercial breeding and seed systems are fundamentally different. Insufficient appreciation of this difference is seen as an important reason for the failure of many attempts to commercialize the public seed production infrastructure. Whereas in development oriented seed systems it is the breeding component that drives the chain, the marketing component takes the primary lead in commercial seed systems (see Figure 1). The result? Each system focuses on different crops and variety types and delivers different products and outcomes.

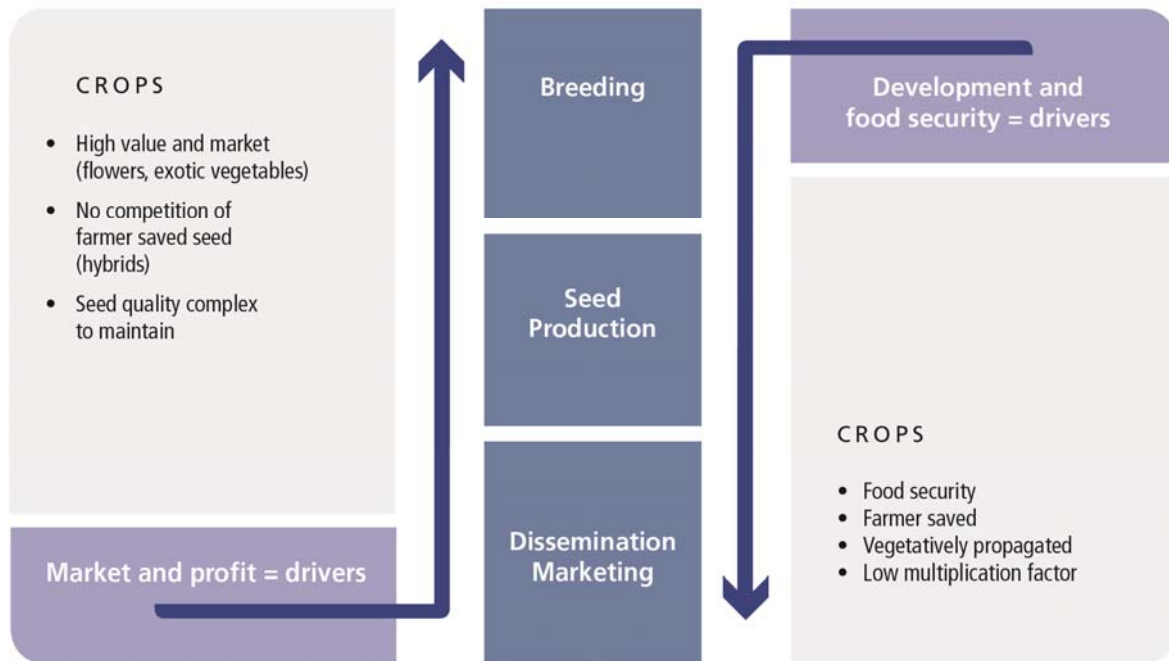


Figure 1: Different drivers and outcomes of commercial and development oriented (public) plant breeding, seed production, and marketing chains (Source: adapted from Louwaars & De Boef, 2012)

The Integrated Seed Sector Development (ISSD) approach is based on accepting that each chain makes particular contributions and plays a role in the development of the seed sector. A more pluralistic view is required that may lead to promoting several complementary pathways to seed sector development. In practice, this means that a range of actors needs to be involved to cover diverse needs and marketing niches. These actors may include private companies that operate at the international or national level and focus on the requirements of more commercial farming enterprises, but also local seed enterprises or farmer groups that offer a range of varieties for local farmer and consumer needs.

The role of governments would be to design enabling policies that foster pluralistic approaches that allow seed sectors to develop. Along with societal actors, projects and programs could be designed that build on diversity in approaches, goals, and driving factors for seed system activities (Louwaars & De Boef, 2012; Scoones & Thompson, 2011).

Innovation in seed systems may thus involve new arrangements and partnerships between actors of formal and informal systems and institutions. These may result in a change of practices beyond what has so far been known as either informal or formal. For example, where farmers engage in producing seed of varieties that require special knowledge and investment to be maintained and reproduced, this seed will need to have a price beyond the normal grain price, whereas this may not be necessary for some other types of farmer-produced seed. Practices originating from the formal seed system, such as variety registration and seed certification rules, may need to be revised to serve various actors' needs. Conceptualizing and positioning seed system innovation and development activities within the ISSD approach could help focus them on achievable goals and clarify objectives among stakeholders.

SORGHUM AND PEARL MILLET CROPS, VARIETIES, AND SEED SYSTEMS IN WEST AFRICA

Sorghum (*Sorghum bicolor*) and pearl millet (*Pennisetum glaucum*) are the most important staple food crops in large parts of Africa. They are essential to the diets of poor people in the semi-arid regions and parts of the sub-humid savannah-like areas of Sub-Saharan Africa, where other crops frequently fail under erratic rainfall conditions. In West Africa, sorghum and pearl millet together are estimated to account for 70 percent of the total cereal production. Both crops together are estimated to account for 75 percent of the caloric intake of resource-poor people in these areas. This is why these crops are of great importance for food and nutrition security, health, poverty alleviation, and food markets, not only quantitatively, but also in terms of nutritional quality (Atokple, 2003; Obilana, 2003). Sorghum and pearl millet are generally used in West Africa for food purpose and to some minor extent, for beverages (local beer). Typical dishes are porridges made from dehulled sorghum and pearl millet grain.

Both sorghum and pearl millet have relatively high protein and mineral contents compared with other cereal grains; however, protein content and quality vary with yield level and agronomic practices, e.g. fertilization and mineral contents of grains depend on soil characteristics (FAO, 1995). Moreover, food processing is an important factor that determines the amount, quality, and uptake of nutrients from food. For example, dehulling and milling reduce the availability of micronutrients, while malting and brewing can increase it.

Considerable genetic variation was found in ICRISAT's germplasm collections with regard to protein, amino acid composition, fat, mineral, and vitamin contents. For example, iron contents vary between 4 and 58 mg/100g in pearl millet accessions and protein contents range between 6 and 21 percent (FAO, 1995). This genetic variation has not been fully exploited in the past, as breeding efforts were mainly focused on productivity improvements with far less attention being given to nutritional quality enhancement (Atokple, 2003).

However, given that under- and malnutrition prevail in the region and that sorghum and pearl millet are important for human diets, it appears crucial to adopt a nutrition-sensitive approach to agricultural and food system development in the future. The number of undernourished people is estimated to be 9 percent in Burkina Faso, 12 percent in Mali, and 20 percent in Niger, with micronutrient deficiencies ("hidden hunger") being much more widespread. Child malnutrition (stunting) is even estimated to be 35 percent for Burkina Faso, 38 percent for Mali, and 46 percent for Niger (SWAC/OECD, 2011).

Pearl millet is grown as a staple crop throughout the Sahelian zone of West Africa, where annual rainfall ranges from 300 to 600 mm. All three project locations visited in Niger are located within this zone, with mean annual rainfall ranging from 310 to 490 mm/a. Sorghum is grown as a staple crop in the Sahelo-Sudanian zone, where annual rainfall is above 600 mm. Kaya in Burkina Faso is the driest among the sorghum study locations, with average annual rainfall ranging from 500 to 650 mm, whereas the other locations in Burkina Faso and Mali all receive more than 750 mm on average.

The region is characterized by high inter-annual rainfall variability, with variable onset of the rainy season, somewhat more predictable endings, and drought or excess water occurrence at any time during the growing season (Haussmann et al., 2012). Climate change is predicted to increase this variability. As anthropogenic climate change interacts with the high inter-annual variation typical for the Sahel region, and with medium-term cycles of dryer and wetter periods, the effects are difficult to predict, and the magnitude, timing, and direction of future rainfall variability patterns are uncertain (Haussmann et al., 2012).

Farmers display a high level of knowledge and awareness of climate change and how it affects their livelihoods. The major indicators reported by farmers included increased temperatures, delayed onset of rains, and insufficient levels of rainfall. They described the major consequences to be lower yields, falling ground water levels, loss of

biodiversity, reduced soil fertility, increased wind and water erosion, decreased quantity of rainfall, and poor rainfall distribution. Other consequences mentioned included flooding, abrupt ending of the rainy season, decreased area of grazing land, higher incidence of hot winds, and changes in surface water quantities, such as drying of rivers, ponds, or wells (ICRISAT, 2009).

The area under cultivation has increased substantially for sorghum and pearl millet crops over the last decades. In Mali, Niger, and Burkina Faso alone, the area cultivated with sorghum increased by nearly 90 percent from 1980 to 2010; in the same period, the area cultivated with pearl millet increased by 65 percent (data from FAOSTAT). This dynamic growth underlines the importance of these crops for the local food systems and economy, particularly in view of the human population growth that is prevalent in these countries. Annual population growth rates of 3 percent in Mali and Burkina Faso and 3.5 percent in Niger are among the highest in the world. Nearly half of the population is below 15 years of age. The total number of people living in Mali, Niger, and Burkina Faso is predicted to increase from 47.7 million people in 2010 to 144.2 million in 2050 (SWAC/OECD, 2011). These figures emphasize the need for developing more productive and efficient agricultural and food systems in the region.

Average yield levels differ between the three countries, thus reflecting the different agroecological conditions. In Niger, the yield level of pearl millet is higher compared to sorghum, which contrasts the situation in Mali and Burkina Faso. For the past three decades, a clear trend toward increasing pearl millet and sorghum yields per area can only be demonstrated for Burkina Faso (Figure 2). In Mali, average yields of both crops are variable but do not show a trend. In Niger, a slight increase can be observed for pearl millet yields, but from a very low yield level.

Sorghum and pearl millet are typically grown in rainfed conditions in West Africa. The most important constraints to production are water scarcity per the highly variable rainfall conditions, poor soil fertility (particularly low phosphorus availability), and biotic stresses such as striga (*Striga hermonthica*, a parasitic weed) or insect pests.

Breeding plays a crucial role in addressing these constraints, particularly in low input farming systems of the semi-arid tropics. In contrast to high input farming systems, where environmental conditions can be to some extent *controlled* by farmers by applying purchased inputs such as fertilizers, pesticides, or irrigation water, low external input systems rely on complex management decisions taken by the farmers with the aim to *adapt* to environmental conditions they basically cannot control (Kaufmann et al., 2013).

Typical adaptation strategies are flexibly using a range of crops and varieties as well as altering planting areas of various crops according to indicators observed by farmers. That is why farmers working under low input conditions are generally very interested in new plant varieties, particularly those that show new and complementary traits. For example, many farmers adopt short-duration varieties from formal breeding programs and use them as a complementary option alongside traditional varieties.

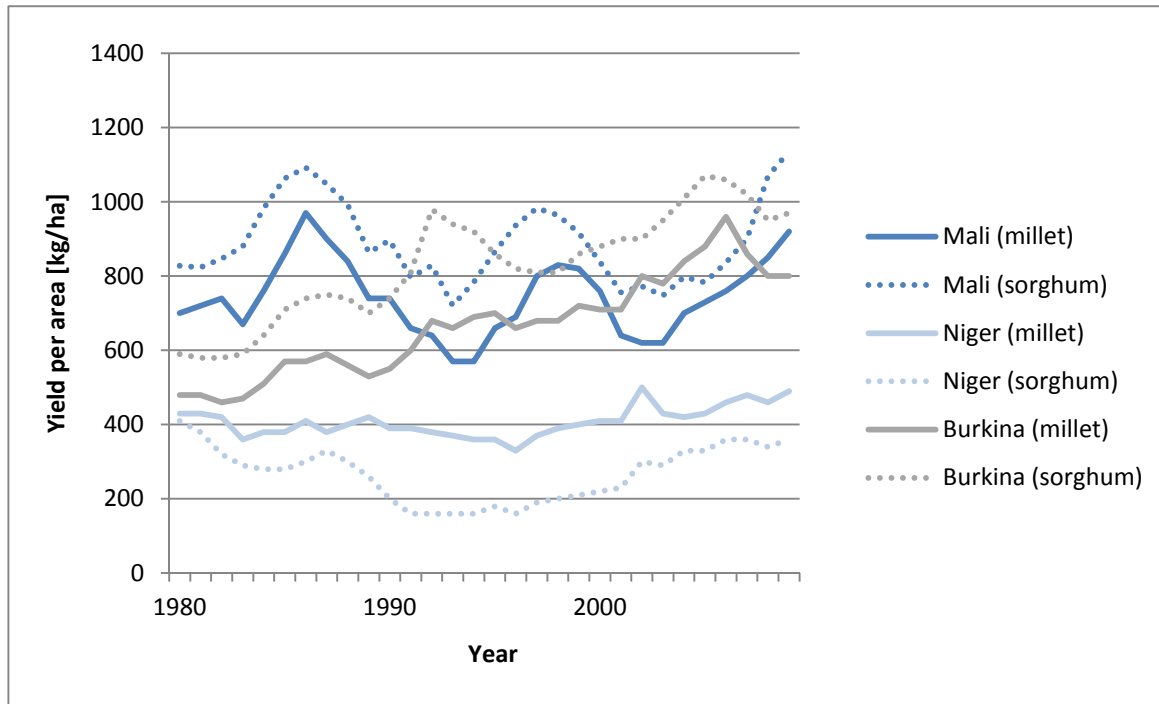


Figure 2: Development of sorghum and pearl millet yields per area [kg/ha] over three decades for Mali, Niger, and Burkina Faso (Data from FAOSTAT; 3-year moving averages)

In view of abiotic and biotic stresses, farmers working under such conditions tend to rely on the inherent buffering capacity of many traditional landraces. Besides having specific adaptive traits, e.g. tolerance to heat or low soil fertility, these varieties also show a plastic response to stresses such as variable rainfall conditions. Haussmann et al. (2012), for example, demonstrated that photoperiodic sensitivity as well as genetic variability with regard to flowering dates can be important traits for enhanced adaptation to changing and variable climatic conditions. As water scarcity also limits the effectiveness of fertilizer use, varieties that are drought tolerant *and* respond to improved soil fertility management are very important for increasing productivity levels in the longer term. Plant breeding is also important to reduce the effects of biotic stresses limiting production. Exploiting existing genetic variation with regard to striga or insect pest tolerance is a promising way of reducing losses. Emphasizing the importance of plant breeding does not, however, mean that other practices such as agronomic measures to control pests, reduce erosion, improve soil fertility, or increase water infiltration are not important. All these measures together can help make low input farming systems more productive and resilient (see, for example, ICRISAT 2009).

Figure 2, shows that such integrated improvement strategies, of which breeding progress should be an important element, have not reached farmers' fields at a relevant scale over the past decades, particularly in Niger and Mali. Even though the dynamic expansion of areas planted may include marginal areas, the data show that research and practical breeding efforts in the past seem not to have addressed in a satisfactory way the conditions faced by farmers.

This is also reflected in the fact that the farmers' adoption of varieties from the formal sector has remained rather low, even though some studies suggest relatively high yield gains for improved varieties of sorghum and pearl millet in West Africa. For example, a synthesis from various adoption and impact studies documents yield gains of 22 percent in Niger and more than 50 percent in Mali (Camara et al., 2006). However, it remains unclear whether these figures are derived from farm-level measurements, variety trials, or other sources. Various improved varie-

ties of sorghum and pearl millet were used by 20 to 50 percent of rural households (depending on which variety) in Niger and Mali, but less in Burkina Faso. Based on the area sown, 30 percent of sorghum area and 37 percent of pearl millet area in Mali were reported to be sown with improved varieties in 1995. Throughout West Africa, improved sorghum varieties are estimated to be grown on 30 percent of the total area sown with this crop (ICRISAT, 2004).

Yapi et al. (2000) state that sorghum and pearl millet breeding in Mali had focused on two different approaches: 1) selection in local landraces, and 2) introduction and use of exotic germplasm. Both approaches resulted in a number of developed varieties. The main achievement of the second approach is shorter duration of some varieties compared with the local landraces. The majority of improved pearl millet and sorghum varieties adopted by farmers were derived from local landraces. The farmers' preference for these varieties traces to environmental adaptation, grain quality, and high stover yield in spite of their lower grain yield potential. Yapi et al. (2000) conclude that "finally, it must be highlighted that although the estimated adoption rates of improved varieties are substantial, age-old landraces of sorghum and pearl millet still remain dominant in farmers' fields." The calculated adoption rates were roughly between 15 and 20 percent in this study for sorghum, and 5 to 25 percent for pearl millet (with regional differences).

ICRISAT's Participatory Plant Breeding (PPB) approach for sorghum and pearl millet breeding seem well justified in this situation, implemented with the national breeding programs since 1998, the PPB projects start from the assumption that farmers have their own complex set of goals, priorities, values, and skills relating to seed selection and use, and that these may be complementary to the standard approach to variety development that assumes production efficiency and market-based value addition are the main goals of crop improvement. Furthermore, plant breeders have sophisticated knowledge of breeding technologies but often lack context-specific knowledge, e.g. on typical constraints faced by resource-poor farmers or relating to crop usage in the local context. Initiating dialogue and combining the expertise of farmers and researchers could thus lead to more relevant outcomes from plant breeding programs, particularly for poor farmers working in marginal environments (Bellon, 2006; Hoffmann et al., 2007). By actively participating in the decentralized evaluation and selection of varieties, farmers gain new, contextualized, and location-specific knowledge about different varieties and their relevance for food and farming systems. This, as mentioned above, is an important prerequisite for creating sustainable demand for seed of new varieties.

One objective of a recent impact assessment study was to update the analysis conducted by Yapi et al. (2000), but also to focus on the recent directions in Mali's sorghum breeding program. The first is the participatory approach to sorghum improvement based on a network of multi-locational, farmer-managed field trials. The second is the development of the first guinea-race, photoperiod-sensitive sorghum hybrids. The analysis consists of two components: 1) a census of sorghum varieties and hybrid seed use parameters, covering sixty villages where farmers have tested materials, and 2) an *ex ante* assessment of the economic impact of sorghum hybrids based on an economic surplus model (see section 4.5, sub-section Efficiency on Page 45 for the latter; Smale et al., 2014).

In the target villages, the total of all improved varieties and hybrids used by farmers has increased to 46 percent. Hybrid use rates averaged upward of 7 percent of new seed types planted by farmers. In the initial year of use, only a small percentage of new seed types were purchased for cash, regardless of the variety type. Since initial use, the mean area planted per farmer has increased for all sorghum variety types, but this is especially true for hybrid seed, which now averages 2 ha per hybrid grower. Thus, there is evidence that farmers integrate the newly developed varieties and hybrids into their variety portfolio and that the pace of adoption is much faster than in the past. Both improved varieties and hybrids are increasingly grown by the farmers.

Thus, establishing a network of participatory breeding and partly farmer-managed evaluation trials has resulted in the identification, enhancement, and release of sorghum and pearl millet varieties and hybrids that perform consistently better than local varieties over a wide range of production conditions. Improving yields and yield stability while maintaining grain quality, selecting varieties specifically adapted to low soil fertility, improving post-harvest traits and nutritional quality, as well as tolerance to striga, are some of the main issues addressed, for which progress has been achieved (Diallo, 2011; Leiser et al., 2012; Haussmann et al., 2012; Rattunde et al., 2013; Kountche et al., 2013).

With the availability of varieties from the public breeding sector that were attractive to farmers, the need arose to create structures to diffuse the seed. Given the absence of a public seed sector that links public breeding system to its customers (as described above) and the farmer organizations already being partners in the variety evaluation trials, their involvement in seed production seemed obvious. Previous experience existed in some of the farmer organizations, particularly in Burkina Faso, where it has been common that farmer organizations produce seed as part of a government seed provision scheme.

A major challenge to be addressed was that seeds of local grains have not historically been considered economic goods in the project region: Seeds are not something to be sold, though non-formal seed transactions are common (Ndjeunga, 2002; Smale et al., 2008; Siart, 2008; Smale et al., 2010). Establishing formal markets and cash-based sales seemed potentially unaligned with habits and history in Sahelian seed systems. Jones (2014) found that diverse seed systems co-exist in the West African region and describes the multiple actions taken by farmers to access seed. Notable is that the most important ways for seed provisioning are *not* based on any sort of commercial value ascribed to it: For farmers, seed is primarily a result of their direct interaction with the natural environment, resulting in the possibility to harvest grain and seed. Furthermore, sharing seed is an important way of accessing seed based entirely on social relations. A number of exchange-based activities, including selling for cash, are also present in informal seed markets.

If farmers buy seed of formal sector varieties, they tend to recycle it over several years and also use it for various informal seed transactions. In this way, the various seed systems nowadays tend to be integrated by being connected and showing some degree of overlap, rather than one system being replaced or incorporated by the other.

Seed spread of formal sector varieties can thus not be captured based on seed sales only: “The diffusion of improved varieties begins through formal exchanges, since implicit in the definition of the type of seed is the type of access activity used to diffuse the seeds. However, secondary seed spread occurs over a much wider range with informal and non-formal seed exchanges” (Jones, 2014: 259).

Current approaches to fostering agricultural development in Africa tend to emphasize seed value chain development and market-oriented formal seed systems as a priority for increasing agricultural productivity and food security. The seed value chains envisioned as a key feature of the second Green Revolution for Africa reflect a general approach to integrate small-scale farmers into global markets and value chains, with little attention given to potential adverse or exclusionary effects (Jones, 2014). Or as stated by the same author: “The rhetoric of market-oriented agricultural development implies that scientifically and economically efficient approaches to agriculture are unequivocally preferable to ‘unimproved’ or non-market based decisions and systems. This rhetoric can lead to an either/or framing of current and changing economic and agricultural systems, in which traditional and also adaptive actions by farmers and communities are evaluated simply based on whether or not modern practices and technologies are present in singular form.” (Jones, 2014: 1)

With this push toward market-oriented seed value chain development, there have been efforts to harmonize seed laws at the national and regional levels in order to avoid disincentives to cross-border seed trade. The seed laws

that were recently passed and that reference international standards effectively tie all sanctioned seed system changes to the dominant value-chain approach to agricultural development (INSAH, 2009).

Regulation C/REG.4/05/2008 on the Harmonization of the Rules Governing Quality Control, Certification and Marketing of Plant Seeds and Seedlings in the Economic Community of West African States (ECOWAS) Region involves the development of a joint variety list and seed certification standards. Implementation of this regulation is supported financially by USAID, and linked to other initiatives, such as the West African Seed Alliance (WASA) via the West African Seed Program (WASP), the Permanent Inter-States Committee for Drought-Control in the Sahel (CILSS), and the Comprehensive Africa Agriculture Development Program (CAADP) established by the African Union. The intention is to build an Alliance for a Seed Industry in West Africa (ASIWA) and implement the ECOWAS seed regulations in the national seed legislation of all member countries.

Whereas the joint variety list could make variety registration from breeding programs easier, a problematic aspect is that the ECOWAS seed regulation largely ignores the existence and importance of the informal seed system. “Quality seed” is being associated only with seed originating from formal breeding programs and agrobiodiversity issues seem to be completely out of consideration. This concept stands in sharp contrast with the reality of small-scale farmers in the West African region. Its impact on the emerging seed markets, and particularly farmer-managed seed initiatives, remains to be observed.

Civil Society organizations criticize that the ECOWAS seed regulation is not compliant with commitments made by the West African countries (including Mali, Niger and Burkina Faso) by signing what is often termed the International Seed Treaty (ITPGRFA), which recognizes the contributions of farmers and farming communities to the conservation and development of crop genetic resources and Farmers’ Rights. The African Centre for Biosafety, for example, blames FAO and the CG Centers for inconsistent actions regarding seed and biodiversity issues, and a lack of commitment to actively promote the goals of the International Seed Treaty (ACB, 2012:29). The authors further warn that the strict implementation of the ECOWAS seed legislation and similar initiatives may lead to severe loss of genetic diversity in Africa.

It can be concluded that the context in which the CCRP project on farmer-managed seed initiatives was implemented is highly complex and subject to changes. Present developments in the seed sector of West African countries are shaped by diverging interests. The question remains as to how they will be linked to related fields, such as genetic diversity conservation, Farmers’ Rights, and the Right to Food, and how the formal registration and certification procedures will be implemented and controlled.

4.2 FUNDING OBJECTIVES, PROJECT DESIGN, AND THEORY OF CHANGE

FUNDING OBJECTIVES OF THE COLLABORATIVE CROP RESEARCH PROGRAM (CCRP)

The Collaborative Crop Research Program (CCRP) vision is “a world in which all people have access to the nutritious food they need on the terms they can afford, and where food is sustainably produced in ways that protect local resources and respect cultural values” (McKnight Foundation, 2011).

To achieve this, the CCRP supports and advances collaborative research on agroecological intensification involving small-scale farmers, researchers, and development practitioners. The CCRP takes a place-based approach, with grantees becoming members of one of four communities of practice (CoPs) based in West Africa, Southern Africa, East and Horn of Africa, and the Andes (CCRP, 2014).

A strong focus is on capacity building and knowledge sharing between all groups and organizations involved. Toward this end, each CoP is supported by a regional team consisting of a regional representative, liaison scientist, monitoring and evaluation specialist, and research methods specialist. The tasks of the regional team include developing strategies, supporting proposal development, building relationships, and fostering collaborative learning via annual meetings and workshops (CCRP, 2014).

With a commitment to continuous learning, the CCRP has created and implemented an Integrated Monitoring, Evaluation, and Planning (IMEP) approach that helps actors in projects to understand achievements and needs, adjust objectives and activities, and mobilize necessary resources. The CCRP further supports the development of research methods for collaborative research approaches (CCRP, 2014).

In West Africa, the CoP focuses on improving food and nutrition security of small-scale farming families in Mali, Niger, and Burkina Faso. It strives to improve variety development of important food crops with regard to productivity and nutritional value, strengthening seed distribution systems, improving agronomic practices, amplifying and diversifying value chains, and improving diets and nutrition of farming families. A list of completed and ongoing projects is available at <http://ccrp.org/west-africa>.

Among other research funding organizations working in the region, the CCRP's focus on transdisciplinary, collaborative research and capacity building are distinctive features. Since the program's inception in 1983, the McKnight Foundation has committed more than \$100 million to the CCRP, of which roughly three-quarters has been assigned to project grants. More recently, the CCRP expanded its activities in partnership with the Bill and Melinda Gates Foundation, which pledged \$50 million to the CCRP for the period 2008–2018 (Cady, 2013; McKnight Foundation, 2014).

PROJECT DESIGN

The CCRP project “Sustainable seed supply: Farmer managed seed marketing initiatives for sorghum and pearl millet in Mali, Niger, and Burkina Faso” started in 2006 (Phase I: 2006–2010); the second phase (2010–2014) is nearing completion, and a third phase has been proposed.

The project has been implemented in three countries, Mali, Niger, and Burkina Faso, and focused on two crops, sorghum and pearl millet. The project was initially and jointly implemented by ICRI-SAT, organizations within the National Agricultural Research System (NARS) of all three countries, and six farmer organizations.

Its starting point: A number of varieties had emerged from collaborative breeding and variety evaluation activities that were better adapted to farmers' conditions and needs than other varieties developed previously under high-input conditions on research stations. These new varieties were in high demand by farmers. The project's practical aim was thus to develop an approach to encourage commercial seed production of farmer-preferred varieties in collaboration with farmer organizations.

The project design can be summarized under objectives, activities, and expected outputs as presented in Table 4a for the first and

“The people of The McKnight Foundation really care about their projects. If there are problems or needs—for additional capacity building, let’s say—they do everything they can to make it possible. This is a big difference [compared] to other funding organizations.”

(A scientist)

Table 4b for the second phase. Whereas the first phase focused on practical activities for increasing farmers' capacities to produce seed, monitor seed quality, and strengthen demand, the second phase focus was to deepen understanding of certain aspects of seed systems and to adapt the approach accordingly. These aspects included gender differences relating to seed access possibilities and ways to improve knowledge dissemination and new seed varieties.

Whereas first phase outputs were strongly related to concrete activities around seed production and marketing, second phase outputs relate to broader issues such as increasing stability of production (systems) and improving nutritional status of vulnerable groups.

Table 4a: Objectives, activities, and planned outputs of the CCRP seed system project for the first phase

Phase 1		
<p>Overall objective</p> <p>To contribute to the development of sustainable seed systems by strengthening farmers' seed commercialization initiatives in Mali, Niger, and Burkina Faso.</p>		
Specific objectives	Activities	Outputs
<p>To strengthen the capacity of farmer groups, networks, and seed cooperatives to produce and distribute increasing quantities of quality seed of a range of sorghum and pearl millet varieties in Mali, Niger, and Burkina Faso.</p>	<p>Each working group (in each country) of this project will prepare an analysis of the local seed system currently in use.</p> <p>Each working group will similarly establish an overview of present grain marketing practices and experiences of farmers and their trading partners in the target zone.</p> <p>Each farmer cooperative will establish in the first year an initial organizational plan to ensure that all key responsibilities of a future seed business are clearly integrated into a single structure.</p>	<p>Farmer cooperatives will:</p> <ol style="list-style-type: none"> 1) Conduct their own variety trials so that they can regularly identify new varieties for distribution in their zone. 2) Produce good quality seeds of a range of cereal varieties, with a satisfactory level of genetic purity. 3) Commercialize seed of this range of different varieties to meet the needs of the farmers in their target zone.
<p>To develop the means and capacities for sustainable monitoring and verification of seed quality.</p>		<ol style="list-style-type: none"> 1) The seed sold by the farmer cooperatives satisfies the needs of users with respect to physical quality and varietal purity. 2) The costs for monitoring and controlling quality and varietal purity are acceptable so that they can be covered by the price of the seed. 3) The seed cooperatives will have established a good reputation for the quality and purity of the seed they put on offer as well as for the stability of the varieties on offer.
<p>To strengthen the linkage of the farmer seed distribution networks with grain processing industries and large-scale wholesalers, thus increasing demand for seed.</p>		<p>Farmer cooperatives will have improved:</p> <ol style="list-style-type: none"> 1) Their overall business and marketing skills 2) Their understanding of options for new developments in the grain market

THEORY OF CHANGE

The project has developed a Theory of Change that makes project outcomes and impact pathways explicit. It relates changes in the seed system to these more general development outcomes:

- improving productivity, yield stability, and income;
- enhancing access to and utilization of improved varieties; and
- reducing malnutrition.

The project aims to achieve this by making available improved varieties to women and men farmers, developing knowledge and methodologies for variety diffusion, and strengthening the capacities of farmer organizations to produce and sell seed. Research questions relating to these issues can be summarized under the three aspects of seed system security: availability, access, and utilization (see Box 1, p. 32).

The Theory of Change thus focuses on the research project and the actors directly involved in the planned activities (researchers, farmer organizations, and farmers). It describes how these actors could contribute to the desired outcomes by creating knowledge, joint understanding, and capacity building.

Table 4b: Objectives, activities, and planned outputs of the CCRP seed system project for the second phase

Phase 2		
<p>Overall objective</p> <p>The project seeks to strengthen the dynamics of local social seed networks so as to improve local seed availability and thus increase the adoption of new sorghum and pearl millet varieties for improved food security and income.</p>		
Specific objectives	Activities	Outputs/outcomes
<p>Improve women (and men) farmers' access to seed of new sorghum and pearl millet varieties in targeted regions of Mali, Niger, and Burkina Faso.</p>	<p>Initiate women's engagement in quality seed production and possibly marketing.</p> <p>Work on methods and tools for better variety evaluation by farmers and farmer associations, including reliable assessment of the quantity of food produced per unit area of harvested crop.</p>	<p>Contribute to improved seed availability in the target areas as well as in similar agroecologies in the participating and neighboring countries.</p>
<p>Understand and enhance the effectiveness of different activities for increasing seed availability and knowledge about the new varieties.</p>	<p>Develop methods and tools for communicating the results of individual site variety evaluations at an appropriate scale.</p> <p>Monitor the variety adoption process, including yearly changes in variety use, and understand farmers' (female and male) responses to climate variability and other changes in the external environment.</p> <p>National scientists will provide seed of new varieties for testing and will ensure that varietal evaluation and monitoring results are collected and used.</p> <p>They will also ensure that foundation seed is available for seed producers and facilitate seed certification.</p> <p>Training and exchange activities will be coordinated within each country by a local coordinator based within one of the partnering farmer organizations.</p> <p>Farmer organizations will continue to improve their seed marketing skills through needs-based training programs (e.g. seed certification, seed marketing, enterprise development).</p> <p>Each country team will hold appropriate planning meetings in the target zones and define options for seed dissemination for testing.</p>	<p>Improve productivity and/or stability of production of pearl millet and sorghum in the target areas.</p> <p>Working with women farmers and with varieties possessing elevated iron and zinc concentrations should enable the project to contribute to improved nutritional status of young children.</p>

Other influencing factors are not addressed with targeted activities. For example, a more general stakeholder analysis and analysis of external factors that might support or hinder the change process have not been included. The involvement of these other stakeholders in the research process appears to be limited to their official functions or institutional relationships with ICRISAT and the national research institutes or to informal contacts between them and the various actors.

4.3 GENERAL RELEVANCE OF THE PROJECT

BOX 1: IMPORTANT RESEARCH QUESTIONS ADDRESSED IN THE PROJECT

Seed availability (production)

- Evaluation methodology: How can farmer cooperatives most effectively choose varieties for multiplication and diffusion?
- Impact: What is the effect of seed production and diffusion on productivity, yield stability, and income?

Access to seed (demand)

- Basic studies on functioning of seed systems in the target region (including gender aspects)
- What factors influence adoption of varieties and demand for seed?
- How can commercialization of seed be organized at the local level and supported by capacity building?

Seed utilization (quality aspects)

- How do post-harvest quality traits influence variety adoption (food yield as an important criterion, particularly of women farmers)?
- Conditions for adoption and utilization of biofortified varieties (rich in Fe or Zn), particularly by women
- Gender roles and their implications for seed and variety utilization: How do project activities change dynamics of traditional seed networks and variety use?

Project relevance can be described as the way in which it relates to the priorities and policies of the stakeholders (e.g. the funding objectives of the donor), the objectives of the research and farmer organizations, and the aims of farmers in the project areas.

In general, the project is relevant because it suggests solutions to prevailing problems of agricultural food and farming systems in the West African region, including stagnating agricultural yields, climate variability and change, scarcity of resources, population growth, and malnutrition. Highly topical in this context is development of access to varieties of staple food crops that are adapted to farmers' needs, help increase and stabilize agricultural production, improve access to staple food, and address nutritional problems.

“Everything is in the hands of farmers: from production of seed, even of source seed, to processing, packaging, and commercialization.”

—Farmer group in Niger

All organizations involved in the project relate their activities to these challenges. The project builds on the actors' shared vision for developing innovations in the seed systems of West African countries—innovations driven by farmers' needs and with farmers as important actors in the emerging seed value chains. Its core activity is the joint development and evaluation of varieties from the public breeding programs that are highly relevant to farmers and help them improve the productivity of their farms and increase their incomes.

The project thus addresses a clear issue: securing farmers' access to quality seed of preferred varieties by tying participatory breeding and variety evaluation to seed enterprises managed by farmers. Besides facilitating the flow of breeding progress from public breeding programs to farmers' fields, this approach offers the opportunity for at least some of the farmer groups to profit from the economic value addition of a formal seed production chain instead of just paying for it. That is why the project has the potential to increase farmers' incomes not only through improving crop yields, but by creating new sources of income in seed production, processing, and marketing.

The project is implemented in an institutional setting involving multiple stakeholders across different sectors, including government, private, and civil society. Uniting the diverse actors — small-scale farmers, farmer cooperatives, private enterprises, national and international research institutions, government agencies — along the seed chain is one of the major challenges. The project aims at setting up new and sustainable cooperation among them and at creating a viable economic base for seed system development.

The project is also relevant scientifically. A number of studies on traditional seed systems describe their strengths and weaknesses and how they are embedded in social systems. Most of these studies conclude that traditional seed systems become weaker and social cohesion more fragile and call for building bridges between the formal and informal systems to improve farmers' access to new varieties and breeding technology. Seed system development is regarded as an important bottleneck for the success of participatory breeding initiatives and public breeding programs in general. However, developing seed systems is a long-term task that implies organizational, political, and economic challenges that go beyond the scope of most breeding programs, thereby limiting their success and impact. The CCRP-funded project on farmer-managed seed initiatives in West Africa provides an important link in addressing this challenge.

With its focus on food security, multi-stakeholder collaboration, capacity building, and learning, the project appears well suited to the objectives and general approach of the CCRP, and clearly relates to the idea of establishing a Community of Practice involving multiple stakeholders. Moreover, it is strongly connected to the concept of agroecological intensification as defined by the CCRP and to the idea of contextualized scaling. In fact, building farmer-led seed enterprises is a possibility for scaling up variety adoption from breeding projects that were also (partly) funded by the CCRP and are part of its broader approach to improving farming system productivity based on agroecological principles.

The CCRP is also very much in line with recent developments in the Consultative Group for International Agricultural Research (CGIAR) global research partnership, where research aims increasingly toward development outcomes. A recent workshop organized jointly by the CGIAR and Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) addressed questions of demand-driven research, uptake, and adoption, and of partnerships for development impact in the larger context of innovation processes (GIZ, 2013). The Feldafing Principles summarize the discussions and focus on innovation as being a multi-dimensional, multi-stakeholder, long-term process that requires building spaces for dialogue and joint learning, and involves strategic capacity building for the different actors in the innovation process. That this form of research for innovation and development needs reorientation not only with regard to research topics but also to methodologies remains to be fully conceptualized. The CCRP could thus be an adequate and qualified partner for implementing and supporting this new type of research.

4.4 SEED SYSTEM DEVELOPMENT

This section documents how the project contributed to developments concerning the various aspects of seed system security: quality, availability, and access to seed. It starts with the quality and utilization aspects, as these relate to the breeding and variety evaluation activities based on which the seed production activities began. It then presents findings on seed availability and access in the study area's seed systems.

SEED QUALITY AND UTILIZATION

Quality as one aspect of seed system security includes various issues: 1) the properties of the varieties being made available through the seed system, e.g. their usefulness in improving productivity and resilience of food and farming systems or for meeting consumers' nutritional requirements, and 2) the technical quality of the seed (varietal purity, germination capacity, cleanliness, and absence of seed-borne pests and diseases).

According to farmers, project activities have strongly contributed to increasing availability of useful varieties. Here, the farmers did not clearly differentiate between the multi-locational testing and variety evaluation system on the one hand and seed production and marketing activities on the other. In fact, both activities offer farmers the possibility to get seed of the new varieties that emerged from the collaborative breeding program. These are adapted to the agroecological conditions, provide higher and stable yields, are drought-tolerant, in some cases resistant to *striga*, have good processing quality and taste, and often offer a shorter duration from sowing to maturity. Farmers can harvest more from the same area and with more or less the same input. The early varieties can be harvested at least one month (four to six weeks) earlier and still combine this advantage with many other preferred traits. This is important to reduce the "hungry period" before the harvest. Hybrid varieties of sorghum, developed recently by IER and ICRISAT, have a clear yield advantage even under low-input conditions. Altogether, these advantages were reported to help families adapt to new (or old) challenges, notably climate change, poor soil fertility, and more cash requirements to pay for necessary services and goods, e.g. medical care, education, housing, mobility, and communication.

Farmers further appreciate that the number and diversity of available varieties have increased. They use different varieties for different purposes and conditions, and welcome the flexibility provided by new and newly available varieties. Many farmers use traditional, improved, and hybrid varieties flexibly to profit from better yields and reduce risk. Multi-locational trials and participatory variety evaluations in villages, including culinary quality tests, attract villager interest beyond members of farmer cooperatives, helping to identify the most promising varieties. Varieties that go into seed production are officially registered once they have been selected by farmers. Preferences vary widely among people from different villages, lending value to the diversity of options and decentralized approach.

One disadvantage mentioned was that some new sorghum varieties are more easily attacked by storage pests compared with traditional varieties. This applies to grain as well as stover, the latter in the case of some new sweet sorghum varieties. Except the open-pollinating line varieties of sorghum, other varieties, such as open-pollinating pearl millet varieties or sorghum hybrids lose their distinctive properties after one or several growing cycles.

Farmers consider the technical quality of seed sold by the farmer cooperatives to be reliable. This judgment aligns with a study that tested technical quality of seed obtained from farmers in the project. The study found that, in most cases, quality was in accordance with official standards (Diallo, no year). In general, farmers tend to rely more on their own assessment of seed quality and their trust in the people providing seed than on stamps or certificates bestowed by government agencies. This gives the farmer seed cooperatives an important competitive advantage,

at least when operating in their local environment where people know the cooperatives and their members. Nevertheless, all farmer cooperatives sell only certified seed because it is required by the new seed legislation and also by some customers, e.g. NGOs and aid organizations.

Given that only a small share of seed used by farmers stems from the formal system to date, an important issue to address is how government institutions could gain or restore confidence while keeping pace with the increasing formalization of the seed market expected under the new legislation. The sealing of bags and packages, for instance, is not commonly applied or it is done in a way that can easily be faked. Agro-dealers do not generally enjoy a good reputation with regard to the quality of seed they sell. Lack of trust in government institutions and other market actors was particularly pronounced in Niger, but less so in Burkina Faso and Mali.

Thus, the issue needs to be addressed of how stakeholders along the seed chain could cooperate in establishing an efficient, transparent system to ensure technical quality of certified seed that supports emerging initiatives and is known and trusted by farmers.

AVAILABILITY AND PRODUCTION OF SEED

Everyone who contributed to the study unanimously opined that the project contributed substantially to increasing the availability of seed of improved varieties in all three countries. Figures provided by the farmer organizations and in reports show that the total amount of seed produced increased, as did the number of varieties available to farmers. In Niger, for instance, only one improved pearl millet variety (cv. HKP) was widely available before the project. Now, three or four more varieties are being produced by farmer organizations.

The time varies since the farmer organizations started engaging in seed production and marketing. Some had started seed production before this project. For example, AMSP in Kaya, Burkina Faso, had already been engaged in seed production since its official formation in 2002, and one individual member had even produced seed before that date. The group around this member, in the village of Zikiémé, has taken leadership in seed production activities to date. Similarly, the organization Fuma Gaskiya in Niger had already started with seed production activities before it became a partner in the CCRP project, beginning on their own initiative and continuing with support from FAO before joining the CCRP-funded project in 2009. The participatory variety evaluation trials played an important role in establishing contacts and creating the motivation to engage in the seed project (see next paragraph). Umbrella organizations uniting several smaller or local farmer organizations, such as AOPP in Mali and MOORIBEN in Niger, helped establish and implement project activities at some locations. Most of the organizations mentioned that they had previous contacts with scientists, either from ICRISAT or their national research institutes, and thus became partners in the project.

All participating farmer organizations are united by a motivation to improve their members' livelihoods. Some take a broader approach that includes not only agricultural production but also education, health, food security, and income for the rural population. Others more focused on agriculture consider it an important means to help their members adapt to climate variability and change the likes of rainfall patterns. Access to seed of improved varieties is considered a major step toward increasing productivity and income. Seed production in itself is seen as an interesting economic opportunity for members, who appreciate being part of an innovation process relating to variety development, seed quality, and "pro-poor" distribution activities. Several respondents mentioned that they could see the opportunity to significantly improve agricultural production and livelihood conditions by producing seed of these varieties and making it available to farmers. One organization (AMSP, Burkina Faso) expressed interest in building up a functioning institutional structure for seed production in the region. Two farmer organizations con-

sider seed production as their most important activity, whereas all others consider it one of several important activities. Interestingly, those who consider it their most important activity are relatively small seed producers.

Figure 3 shows the amount of seed produced by the farmer organizations for the last five years. Production has increased steadily or even dynamically for COOPROSEM and ULPC (both Mali), AMSP (Kaya, Burkina Faso), and MADDABEN in Falwel (Niger). It shows a little more variation or a slight decrease between 2012 and 2013 for UGCPA (Dédougou, Burkina Faso) as well as for the organizations HAREYBEN in Tera and Fuma Gaskiya in Serkinhoussa (both Niger).

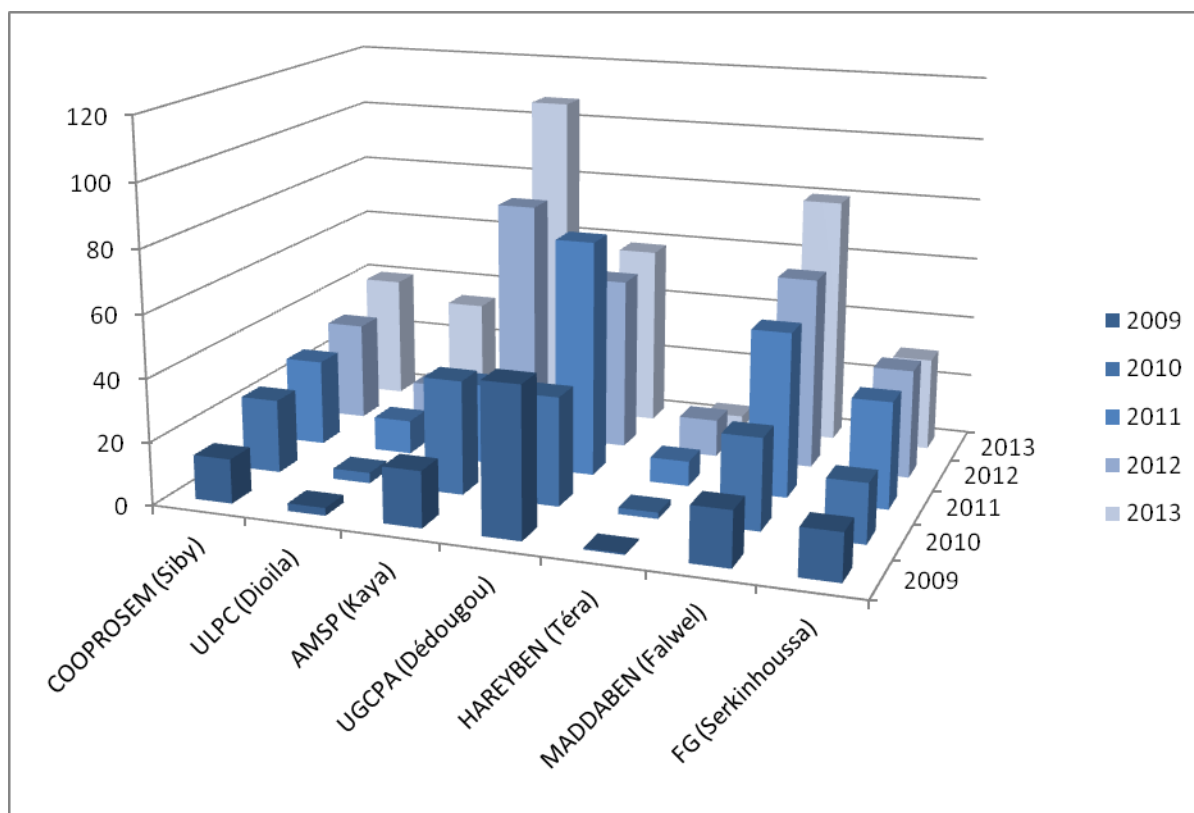


Figure 3: Seed produced [tonne] by different farmer organizations from 2009 to 2013; based on information from questionnaires (NOTE: FG=Fuma Gaskiya)

The farmers organizations above represent relatively large seed producers, such as UGCPA in Burkina Faso, producing 55-75 t of sorghum seed annually; AMSP in Burkina Faso, producing 107 t in 2013; or MADDABEN in Niger, producing 80 t of millet seed in 2013. At the same time, there are medium-sized seed producers such as COOPROSEM and Fuma Gaskiya, as well as small producers, such as HAREYBEN in Téra (Niger) with a maximum of 12 t millet seed produced in 2012.

In terms of area, the total amount of seed produced by these farmer organizations in 2013 is sufficient for sowing 16000 ha of sorghum and 11500 ha of pearl millet. This rough estimate is based on sowing rates of 15 kg/ha for sorghum and 10 kg/ha for pearl millet. The amount of seed sown per unit area depends, *inter alia*, on field conditions and time of sowing.

Whereas some seed producers concentrate on sorghum or pearl millet, others produce and offer seed of various crops, including several varieties of these. Table 5 shows the number of varieties of each crop produced by the

farmer organizations in 2013. These include own initiative or seed produced in cooperation with other projects. The number of varieties and which varieties fluctuate year to year. In Burkina Faso, difficulties in obtaining supplies of source seed of farmer-preferred varieties were reported, a problem that limits the diversity of varieties produced (e.g. if compared with the situation in Mali). Some farmer groups additionally produced seed of hybrid parents or other breeder seed.

The number of seed producers was not collected from all organizations and varies by year. For AMSP in Burkina Faso, the organization that produced the largest amount of seed in 2013, the situation was described as follows: The sorghum seed production activities started with one person in one village producing seed on 1 ha of land in 2001. In the following years, two to three farmers of that same village produced seed, each farmer on 1 ha of land.

Table 5: Number of varieties per crop of which seed was produced by farmer organizations in 2013 (x= seed of this crop offered; number of varieties unspecified)

Crop	COOPROSEM	ULPC	AMSP	UGCPA	HAREYBEN	MADDABEN	Fuma Gaskiya
Pearl millet			x	1	2	3	5
Sorghum	13*	24	5	3			2
Sesame			x				
Cowpea			x			2	3
Maize	x	2		3			
Groundnut	2						4
Rice	1						

*8 varieties, 5 hybrids

After the CCRP-funded project started, the number of seed producers increased to about fifteen, of which two were women farmers. In the project's second phase, the number grew to ca. 30 (of which two or three were women), producing seed on ca. 80 ha of land. This means that not only the number of farmers increased but also the area of land each farmer used for seed production. Additionally, millet seed was produced by twenty-three AMSP members, of which seven were women. However, the number of women seed producers dropped sharply in 2011 when a minimum production area of 3 ha was defined by new certification rules. Many women have limited access to land and, thus, tend to be excluded by the official standards and rules, making the number of seed producers per organization generally not very high. For example, COOPROSEM in Siby, a medium-sized organization with regard to seed production, had twenty-one seed producers in 2011.

“Commercialization is one of the major handicaps of our organization. We have large enterprises as counterparts that buy tons of seed on credit and do not pay even after one year. We do not know how to enforce our rights. Phone calls have remained useless.”

—Member of a farmer organization in Mali

All farmer organizations use multiple channels for marketing, including seed sales to 1) individual farmers, 2) retailers, e.g. seed societies in Mali and private companies in Niger, 3) aid organizations and NGOs, 4) the state (in Burkina Faso). The relative importance of these marketing pathways differs for each organization. Whereas HAREYBEN in Téra (Niger) and UGCPA in Dédougou (Burkina Faso) focus on sales to individual farmers (most of whom are members of the organization in the case of UGCPA), retailers are important clients for MADDABEN in Falwel (Niger), ULPC in Dioila (Mali), and COOPROSEM in Siby (Mali). Fuma Gaskiya in Serkinhoussa (Niger) sells the greatest share of the seed produced to aid organizations, whereas the state and NGOs are the most important clients for AMSP in Kaya (Burkina Faso).

There does not seem to be a general lack of demand, as the seed produced is also sold by the organizations in nearly all cases. However, it requires effort, particularly to increase or stabilize the amount of seed sold to individual farmers.

Members of the farmer organizations have substantially improved their expertise and competencies for producing quality seed. They relate this directly to the training, technical advice, exchange visits, and contacts with scientists that the project facilitated. Their most important problems presently are: 1) provision of source seed, 2) growing needs for appropriate storage and processing facilities, 3) improved commercialization to ensure sustainability of the activities, and 4) outstanding debts and delayed payment. Not all problems are relevant to all farmer organizations.

Supply of source seed for a range of varieties seems to be a problem in Burkina Faso particularly. Unfortunately, the underlying reasons could not be explored because the responsible person was unavailable at the time of evaluation. Based on information provided by the farmer organizations, it seems to be a mixture of difficulties in planning the demand and in availability of funds.

With the increasing amount of seed produced by the farmer organizations, storage and processing facilities need to be expanded. This requires investment, as is the case with marketing activities. Problems concerning reliability of some market partners are potentially relevant to those organizations that sell larger amounts of seed to retailers. The farmer organization ULPC in Dioila (Mali), for instance, has not received payment from a large dealer (Mali Paysan) for more than a year, but there do not seem to be clear mechanisms for effectively claiming payment of delivered goods; that, or farmers lack experience with such situations.

ACCESS TO AND DEMAND FOR SEED

As mentioned earlier, it is not traditional practice in the West African region to buy seed of staple food crops such as sorghum and pearl millet. Besides seed provisioning from informal sources if own seed is scarce or of insufficient quality, seed purchase is mainly motivated by farmer interest in growing new varieties.

That explains the tendency toward increased demand, which is far from stable and predictable. According to farmer study participants in Mali, farmers make their decisions concerning variety shortly before sowing. In good rainfall years, that means early onset of the rainy season, when farmers use local varieties and shift to improved varieties with a shorter growing cycle if the onset of rainfall

“We actually see an increased interest in new varieties in the year following a bad season because some farmers may not have harvested grain that is of good seed quality (small grains due to drought), or their food stocks are low and they want [to] have a sorghum variety for an earlier harvest to break the hungry season earlier.

—Scientist

is delayed. This makes it difficult to calculate and respond in advance to demand for different varieties. Storage of larger stocks and over several years would be necessary to buffer the variable demand that depends on the region's climate variability.

In those villages where seed production takes place in clusters of neighboring villages as well as surrounding areas, farmers have gained access to seed of several improved varieties based on project activities. This is particularly relevant for Niger, where only one relevant improved variety of pearl millet (HKP) was widely available previously. Farmer cooperatives have developed and tested various strategies for increasing demand and facilitating access: regular market stalls, mobile seed shops, seed fairs, village shops, collaboration with intermediate and wholesale traders or government agencies. Some of these activities, however, are still in their initial stages.

One approach to seed dissemination taken by the CCRP-funded project has been promoting mini-packets of new varieties of sorghum and pearl millet seeds. At 100 grams each, these mini-packets cost between FCFA 50 and 100, equivalent to U.S. 10 to 20 cents, respectively. One mini-packet is sufficient for sowing two or three rows of 100 m each.

Poor farmers' access to new varieties is much facilitated by the mini-packet approach: Small packages sold locally at an affordable price are highly appreciated for testing and experimental purposes. The idea is to address the contextual constraints to the adoption of new improved varieties, which in Sahelian West Africa includes low rates of available cash and high opportunity cost for trying something new and unknown (Jones, 2014).

In the case of open pollinating varieties of sorghum, the seed from the mini-packages can be multiplied, harvested, and reused over several seasons. For pearl millet, being a highly cross-pollinating crop, it is more difficult to maintain varietal characteristics on-farm, depending on the size of field plots and proximity and flowering times of other varieties in neighboring fields. In general, farmers can maintain the seed over longer periods by performing selection.

Selling mini-packages can involve high transaction costs for the farmer organizations selling them. That is why approaches such as mobile seed shops and seed fairs, as well as selling them in general village stores, still need to be fully assessed in order to learn about the potentials and limitations.

Another way to facilitate poor farmers' access to improved varieties are seed distribution plans run by governments and aid organizations. For instance, the Confédération Paysanne du Faso (CPF), an umbrella organization of several farmer organizations in Burkina Faso, demands that the government subsidize seed prices in order to facilitate poor farmers' access to seed of improved varieties. Such distribution schemes result in a very low seed price—U.S. \$2 for 15 kg of seed—compared with approximately U.S. \$10 to \$30 for the same amount if purchased from a farmer organization.

Seed distributed via these government schemes and similar activities of aid organizations is not always recognized as high quality seed by those who receive it, particularly if it is distributed without labels and information on the variety. Parts of the seed may be consumed and not used for seed purpose, resulting in lost impact with regard to the breeding progress achieved. At the same time, it has been reported that the sorghum variety Gnessiconi has become widely known because of this distribution pathway.

Because there may be limits to the economic feasibility of fulfilling seed requirements of poor farmers via value chains, the distribution of seed via government programs and/or aid agencies may be necessary as a complementary distribution pathway. This is based on the public interest in making seed of these varieties available to farmers

who lack purchasing power to buy the seed regularly. However, cooperation between farmer organizations and public or aid organizations needs to be better defined to avoid competition and loss of valuable seed.

With regard to access to information on varieties, the evaluation trials continue to play an important role. In Mali and Niger, activities with local radio stations helped raise farmer awareness of the availability of the new varieties and ways to access the seed.

In her doctoral thesis, Krystal Jones looked into the access decisions of various groups of farmers, distinguishing three important pathways for them to access seed of the varieties developed by ICRISAT's sorghum and pearl millet breeding program together with the national research institutes: 1) conducting variety evaluation trials for which seed is provided by the plant breeders, 2) purchasing mini-packets, and 3) getting seed via exchange or as a gift from the original buyers or testers. The results suggest that secondary seed spread mentioned under 3) occurs at much broader scale than the other two pathways (Jones, 2014).

Farmers in Jones' study were generally ambivalent about changing from a system of sharing and exchanging seed among socially close people toward buying seed in shops and on markets. But the advantages were also clearly mentioned: 1) saving time, because visiting friends or relatives may involve, say, travel time, 2) more choice among varieties with different characteristics, and 3) more or new information. Farmers have to gain their own experience with, for example, varieties losing key traits after several seasons and also with the fact that accessing seed, even informally, has become more complex. Farmers who invest time and money in producing seed of improved varieties do not just give them away, as was the rule earlier. The means through which people in need can access seed depends on many factors, and their decision as to which path to follow are made flexibly. There is no indication that women are excluded from certain access pathways, but a potential for exclusion exists based on an individual's social position, resources, and skills (Jones, 2013).

Farmer organizations find themselves in transition: Demand for seed is increasing, but not very fast. The effects of new seed legislation on secondary seed spread as an important access pathway remain to be seen. The market segments reachable via the mini-packet approach and collaboration with state and aid organizations are not yet well defined.

4.5 DEVELOPMENT IMPACTS

This section summarizes the results regarding four criteria: effectiveness, impact, efficiency, and sustainability.

EFFECTIVENESS

Effectiveness here is a measure of the extent to which a project attains its objectives. To what degree have the project's objectives been achieved or are anticipated to be, and what factors are responsible for their achievement or failure?

The general objectives were framed as "to contribute to the development of sustainable seed systems by strengthening farmers' seed commercialization initiatives in Niger, Burkina Faso, and Mali" for the first phase, and "to strengthen the dynamics of local social seed networks so as to improve local seed availability and thus increase the adoption of new sorghum and pearl millet varieties for improved food security and income" for the second phase.

As listed in Box 2, project activities for reaching these objectives included participatory variety evaluation, activities relating to seed production and processing, and seed diffusion and marketing. Being a research project, a strong focus was on developing and testing appropriate methodologies for each activity. They further included capacity building to support organizational learning.

The objectives were achieved or are likely to be achieved to a high degree. Farmer-led seed commercialization initiatives exist in all three countries, producing certified seed enough for sowing roughly 27 500 ha of agricultural land. Seed commercialization initiatives improved availability of seed and thereby facilitated variety adoption. Given the proven advantages of these varieties with regard to yield, yield stability, and quality, an impact on food security and income is likely to be achieved (see also next section, Impact).

Activities relating to variety evaluation and technical aspects of seed production are highly effective. In this regard, the close connection between participatory variety evaluation, seed production, and dissemination have contributed to the success. Activities for post-harvest processing, certification, and marketing still experience difficulties, at least for some organizations, and in seed marketing to individual farmers. A more precise definition and coordination of strategies, particularly in view of competing initiatives of government programs and aid agencies, could support these activities.

Project success depends greatly on external factors and the cooperation between stakeholders operating at various levels. That is why the influencing factors and stakeholder relations need to be fully conceptualized and targeted with appropriate activities in a possible next phase.

BOX 2: PROJECT ACTIVITIES

- Establish variety evaluation trials in villages
- Participatory variety evaluation, including post-harvest and culinary traits
- Technical support provided by advisers employed by the farmer cooperatives
- Support to organizational learning, e.g. committees for fixing seed price
- Information and training on seed certification
- Registration of producer groups at certification agencies
- Field inspection and seed harvest according to norms
- Processing and packaging in mini bags with labels
- Organization of field days, publicity, radio broadcasts
- Organization of seed fairs
- Offering seed at local shops or markets
- Offering seed via mobile seed shops
- Producing technical information sheets in local languages

IMPACT

Impact describes the positive and negative changes produced by a project. This involves the main effects resulting from project activities on indicators usually predefined to cover various dimensions, including, for example, economic, social, or ecological.

This study employed an approach that does not use predefined indicators: the Most Significant Change (MSC) technique (see Section 3) for documenting statements or stories of impact from discussions with farmer groups. In a reflection following these discussions, impact stories were grouped into four domains: 1) impact relating to variety adoption and seed systems, 2) impact relating to productivity, income, and nutrition, 3) impact relating to knowledge, innovation, and development capacities; and 4) potential negative impacts. Farmer statements are presented for all domains, along with additional information from interviews with farmer groups and partners such as researchers.

IMPACT RELATING TO VARIETY ADOPTION AND SEED SYSTEMS

Both farmer organizations and individual farmers, including women, conduct variety tests and participate in evaluations with obvious interest. They appreciate the participatory approach because they can observe variety performance and traits in the field. By comparing them over several years under variable climatic conditions, they can develop their own judgments regarding the strengths and weaknesses of different varieties.

Seed production has increased and continues to grow from year to year. This growth is based on the increasing numbers of farmer seed producers. Organization leaders have recently started reflecting on an optimum number of seed producers. Farmers with less land also participate in seed production activities by cooperating with neighbors in order to meet the 3 to 5 ha minimum area requirement. Isolation of plots for seed production is not always easily achieved, particularly in more densely populated areas. However, it is common to give seed of the same varieties to neighbors in order to reduce unwanted cross-pollination with other varieties.

It has become easier for farmers to access seed of improved varieties. This, in turn, has an impact on variety adoption. Farmers and farmer groups who participated in the study estimated that adoption and utilization of the new varieties was 25 to 50 percent in the villages where seed was produced, 5 to 15 percent in clusters of neighboring villages, and 2 to 10 percent countrywide. INRAN scientists estimated that adoption of improved pearl millet varieties countrywide in Niger had increased from 3 to 4 percent in 2004 to 10 to 12 percent in 2013.

IMPACT RELATING TO AGRICULTURAL PRODUCTIVITY, INCOME, AND NUTRITION

Improved yields, particularly in sorghum, have saved the crop from being replaced by maize and cotton. In some villages of Mali and Burkina Faso, farmers diversified their farms by replacing cotton with sorghum seed production. By using the improved varieties, the crop has become profitable again and, according to farmers, yields are more stable. The improved varieties respond better to fertilizer, are more tolerant to variable rainfall conditions, and are more productive. Many of them are multifunctional in that they combine shorter duration, higher yields, and better fodder quality for livestock. Altogether, these advantages result in better food security and income.

"If people see the improved varieties growing well in the field, many want to try them."

"It is easier to get seed now – in the past we had to go from village to village, but now they are close."

"In the past, you had to search for seed of specific varieties in case of need – now we know the places where we can get it."

"You don't exchange seed of new varieties, you buy it."

The fact that the number of farmers wishing to join project activities is on the rise shows the high interest. Seed production is perceived as more lucrative than grain production, and the knowledge gained (on varieties, seed storage, etc.) helps farmers improve their own cereal production. Farmers report yield increases of 10 to 20 percent if improved varieties of sorghum and pearl millet are used, and up to 50 percent (in that case, from 800 kg/ha previously to 1200 kg/ha now) if combined with improved cultivation practices such as fertilization and improved manual weed control. Improved yield and income have helped some farmers invest in animal traction, improving their efficiency and reducing dependency on hired labor.

For the men, the most significant change they associate with the project is improved productivity and income as well as increased food security. They have improved the livelihood of their families by being able to invest more in educating their children, in housing, and in buying more land. They are now able to pay in a timely manner for necessary expenses relating to health care, religious ceremonies, and taxes (without taking loans), and can spend more money on clothes or mobile phones. The money they spend helps other villagers such as craftsmen and service providers.

“Not only do we harvest more and eat well, the animals also eat well. With the new sweet sorghum variety, the animals grow better and investing in livestock is a good choice now.”

*—Farmer in Kaya,
Burkina Faso*

“We have produced so much that all the shops in the village are full ... some bags are even stored in the health center of our village.”

*—Farmer in Kaya,
Burkina Faso*

Women farmers highlight improved life conditions, particularly relating to food and nutrition for themselves, their children, and other family members. Nutrition improvements result not only from the new varieties but also from the training courses. The additional income women get from seed production or other activities started along with growing the new varieties (e.g. selling flour and other processed products) helps fulfill their and their children's modest needs, improving meals and more easily covering necessary expenses.

"I personally think that seed production is more profitable than grain production and gives us sufficient revenues to realize our lives. The only problem is that the seed does not give us income timely enough. We have to wait for months to get the certification and then again for selling, and the market is not reliable."

*—Farmer in
Magnabougou, Mali*

"The most significant and surprising change is that ... there are no agricultural workers any more in the villages— everybody works for their own family. This can be explained by more food and more money ... The hope to harvest inspires us to invest in our own work. We invest in agricultural inputs, quality seed—not only of millet, but also of cowpea and groundnut ... in order to increase our income, even without salary. Several households own harnessed teams now [animal traction]."

—Man in Falwel, Niger

"A certain redistribution [of income] also occurs in the village because we can give more to the poor. The Zakat [dime] of the production we get is now being distributed to the poor. Earlier, we did not give because we did not dare to take the risk. We also give a share of the harvest to our women's braiders [tresseuses]. The increased income also helps to develop some other branches, such as masonry and tailoring..."

Farmer in Téra, Niger

"In our area, a significant change is that the land area for seed production is increasing. Even I, being a woman, started with 2 ha of seed production and I had rented the rest. But now I own 4 ha and I expect to buy more from my neighbors The land price is quite high, and everybody now wants to have 5 ha in one single plot"

*—Woman in
Maradi, Niger*

Impact relating to knowledge, innovation, and development capacity

The seed producers understand the certification procedures and necessary quality standards and are able to comply with them. The technical advisers are highly motivated and held in high esteem by the farmers, but field visits can be delayed in some cases, as the advisers tend to be overcharged with work. All farmers participating in the study agreed that their technical knowledge, professional skills, and production had increased, while the number of fields and seed lots rejected for not meeting quality requirements had decreased. The latter was related to the project's support and training.

The seed producers are well known in the surrounding villages for being advanced farmers with good harvests. They enjoy good reputations as being trustworthy people and regard themselves as experts in agricultural production. In some cases they are consulted by government officials seeking technical information such as that relating to the demonstration trials (information from a focus group discussion at Falwel, Niger).

Some farmers have started to produce seed of other crops (maize, vegetables) based on the technical knowledge they gained. Some farmers also engage in selling seed and fertilizer. They are active members of their cooperative, giving advice to other farmers or belonging to official agricultural bodies.

Some men farmers stated that their view of agriculture had changed, understanding it now to be ambitious professional work that requires knowledge and compliance with technical standards and norms. This change in attitude also concerns their children. Family members put forth a lot of effort getting information and improved seed, not only of sorghum and pearl millet but also of other crops, mainly cowpea, groundnut, and vegetables. Some farmers from Kaya in Burkina Faso even went to Galmi in Niger to purchase onion seed based on information provided by a seed producer in Kaya, Burkina Faso.

Women farmers appreciate the benefits and capacities gained regarding technical agriculture knowledge and their awareness of change in general. For them, the most significant change is the mobility they gained through project activities, which is a form of empowerment.

NEGATIVE IMPACTS

Participating farmers were unable to report any substantial negative impacts of the project besides a general envy that may occur if some people successfully participate in new activities and others do not.

"Now I see the differences between different seed qualities. Earlier, I thought that we could sow any grains after the first good rainfall. And if the harvest was low, I thought it was due to the soil having been exploited for so many thousands of years ... Today, I know that poor seed quality is also one factor contributing to low yields. We were simply farmers without knowledge, and this ignorance is the cause of our poverty."

—Farmer in Dédougou, Burkina Faso

"With the pluviometers, we sow just in time after the second good rainfall. We have finished with sowing too early and resowing."

—Farmer in Falwel, Niger

"The training for change is a real trump card because it helped us to diversify the meals. The enriched food helps us to better feed our children and, above all, to recover those who are malnourished."

—Woman from Siby, Mali

"Earlier our husbands did not let us leave the house without permission. But now, with the many trainings and exchange visits organized, the husbands do not try any more to impede us from leaving the village. We can go out and follow our various occupations."

—Woman in Falwel, Niger, focus group

Researchers stated that impact may be lost when good quality seed is distributed to poor farmers without the necessary information and used for food instead of sowing. It is not known to what degree this really happens.

A potential negative impact stated by researchers is that growing new, highly productive varieties without adapting soil fertility management could, in the long run, result in a depletion of soil nutrients and decreasing productivity.

EFFICIENCY

Efficiency is an economic term measuring project outputs relative to inputs. Looking at efficiency thus aims to make sure that the least costly resources are used to achieve the desired results. This generally requires comparing alternative approaches to see whether the most efficient process has been adopted.

Conducting an assessment based on economic data went beyond the scope of this study, which was mainly based on qualitative information. Economic assessments are, however, available from other studies that focus on breeding activities. *Ex ante* assessments of economic surplus achieved through breeding rely on a number of variables that can only be estimated, an important one being successful seed delivery (M. Smale, pers. Comm.). The approach taken by the project—combining farmer-managed variety evaluation and seed production—could be regarded as an important building block that helps the breeding program achieve its full impact. As mentioned, variety adoption and seed delivery have in the past been important bottlenecks.

An ongoing study conducted by Smale et al. (2014) focuses on the guinea-race sorghum hybrids from ICRISAT's collaborative breeding program. For the expanded project lifetime, including the period 2000–2025 for cost streams and 2009–2025 for benefit streams, the present value of gross benefits of guinea-race sorghum hybrids research and seed provision is estimated at more than U.S. \$54 million in the target zones alone. The net long-term benefits are estimated at U.S. \$52 million. The long-term rate of return is projected at 36 percent per year with a benefit–cost ratio of 40:1, indicating that each dollar invested in the pilot project to develop guinea-race sorghum hybrids in Mali generates U.S. \$39 of net benefits. The evidence implies highly cost effective research from this particular pilot project, depending on successful seed production and dissemination.

In view of the impacts described, the CCRP-funded seed production project appears highly efficient. Not only has the variety adoption progressed at a faster pace than in the past, but the focus on facilitating experiential and contextualized learning on varieties and seed production seems to have a more general influence on farmers' decision-making regarding variety use and production improvement.

With a total annual funding of roughly U.S. \$100,000 to \$150,000, distributed to a number of partners in three countries, it is a relatively small project, particularly when compared to previous efforts to build up formal seed supply systems in the region. For example, investment in formal seed supply was estimated to total up to U.S. \$45 million in Niger alone, with very modest results in the contribution of formally produced seed to farmers' seed supply (Ndjeunga, 2002; Ndjeunga et al., 2006). The problem of the project studied here is definitely not wasted funds but the opposite: insufficient funding.

The project does not cover the full cost of the activities. This may be intentional, in order to mobilize other resources. Instead of doing so, however, this funding practice could also lead to lack of project support or to slow progress. In a few cases it was reported that additional funds could be acquired, such as for a seed storage facility. This seems to be an exception versus routine. In some villages, local assistants (“animateurs”) work on a voluntary basis, but some statements indicated that, not surprisingly, they work more efficiently when paid an allowance.

At ICRISAT, full cost recovery is explicitly demanded per the organization's funding requirements. Not responding to it may not be the best path to efficient cooperation in the longer term. Co-funding and building on synergies were applied to partly solve this problem and, in fact, the project has profited from linkages with other projects, such as the An Be Jigi or the HOPE project and another project working on improved cultivation and fertilization practices.

SUSTAINABILITY

Sustainability refers to the social, ecological, and economic aspects of project development that influence its potential to continue after funding has been reduced or withdrawn. For the CCRP-funded seed project in West Africa, we see positive developments as well as open questions relating to these three aspects of sustainability.

Varieties have been successfully developed and tested that respond to farmer needs and help increase productivity and diversification of farming systems under variable and changing climatic conditions. Given the ecological, economic, and social significance of farming in the target area, this alone is an important contributor to sustainability. At the same time, it remains to be seen whether the higher yield levels of improved varieties require other changes in farming systems in order to maintain effect, particularly soil fertility management. This issue is already being addressed by other ongoing research, some of which is funded by the CCRP within its West Africa Community of Practice.

The shift from traditional ways of provisioning toward regularly purchasing seed of improved varieties or new hybrids raises questions regarding the effects on traditional seed systems and food security of vulnerable groups. As long as informal pathways of accessing seed exist and are legal, this may not be a major problem. However, promoting the emerging farmer-managed seed value chains could be considered an activity that is embedded in a broader approach to Integrated Seed System Development: The seed value chains would be purposely connected to other measures, e.g. those that guarantee access to seed for vulnerable groups. Government programs and aid organizations could be important partners in this regard.

Farmers have profited economically from project activities, both in their roles as seed producers and users. That said, the demand for improved sorghum and pearl millet seed from individual farmers remains limited and most of the seed produced is sold to AGRA-supported seed distribution companies, government agencies, and NGOs. Furthermore, the distribution pathways of the government schemes and NGOs do not seem well coordinated with the emerging seed value chains. The same seed could be available from different sources under very different conditions. Farmer-managed seed production also depends on the availability of source seed provided. The responsibilities for decision-making as to amounts to produce of which varieties, and how this could be coordinated with variable demand, must be addressed to reduce risks for the farmer organizations.

The price at which seed is currently sold probably does not cover its full production cost. It is therefore important to put more focus on this issue and raise awareness of the full cost of good quality seed among producers and clients. Investment in storage and processing facilities is necessary, but dependency on external factors (e.g. how the new seed legislation will be implemented and how it might affect the farmer seed initiatives in each country) increases risk associated with investments. Weak financial reserves comprise a high risk for farmer organizations and individual producers; if payments do not arrive on time, the organizations' capacity to buffer such losses is easily exceeded.

Seed production activities appear to be well integrated in the overall activities of the farmer organizations. Client trust in the quality of farmer-produced seed is high. All respondents highlighted and appreciated the improved

relations between farmers, farmer organizations, and research institutions. At the same time, there are doubts whether the institutionalization of the collaboration is strong enough to survive if key people leave their organizations and whether the participatory approach has been sufficiently understood, internalized, and valued by other researchers, e.g. within ICRISAT as well as national research institutes.

In spite of the many and important positive attainments, sustainability is the major challenge ahead, and several issues urgently need to be addressed so as not to lose the positive impact achieved so far.

4.6 CCRP CONTRIBUTIONS

A first and very important contribution of the CCRP is that, with its overall approach and funding strategy, it actively contributes to the development and implementation of research methods that relate to current understandings of innovation and change processes. To reach impact on the ground, it is not only researchers who need to gain new insights on the functioning of food and farming systems, but also the actors in these systems. The common perspective of farming systems is mainly that of production systems that can be enhanced with innovative technologies. Complementing this is a focus on them as human activity systems in which people's goals, needs, values, and capacities play major roles.

In this type of actor-oriented approach, participation is not only needed to increase client-orientation and facilitate adoption of technologies, such as new varieties. Rather, it subscribes to the premise that real-world changes can occur if the relevant actors collectively change their actions. In the case of this study, these would be all actors along the seed chain. In order to achieve such change, experiential learning, testing, and capacity building play key roles. Transformation knowledge is collective knowledge that is needed to change from one situation to another, and it includes technological knowledge along with practical and organizational skills, plus the resources and capacities required for a successful transformation (for example, see Kaufmann et al., 2013).

"It is still not easy to find donors who understand that this is research."

—*Scientist*

By facilitating exchange between actors, the needs for adapting research and capacity building according to the desired impacts can be defined and adjusted throughout the project lifetime. In this project, the technical advisors (*conseillers techniques*) have an important role toward that end. They implement project activities on the ground, facilitate field research, and help document results in a systematic way. They enhance links and flow of information among farmers, farmer organizations, and researchers.

Participants from all organizations stated that the capacity building helped them develop their activities beyond the project itself. Farmers appreciated the project's capacity building, training, and support relating to the technical aspects of seed production. They greatly valued gaining capacity to collaborate with officials, researchers, and authorities, and being recognized as experts who serve as role models and guide others.

How this actually influences their activities and behavior is difficult to grasp. Examples mentioned were that some small producers, particularly women, formed groups to continue seed production when the minimum area was set to 3 ha. Members of seed producer groups in Burkina Faso reflected jointly on how best to cover seed certification cost before getting any revenue from seed selling. Women in particular valued the "training for change" in which they had participated, citing that it increased their mobility and freedom to take up their own activities.

These examples show that people, individually and collectively, strive for solutions to challenges they meet and that the capacity for doing so is most likely not limited to a particular project activity. Yet it cannot easily be ascribed to any particular training they obtained. Rather, it could be considered a general empowerment gained through collective action and capacity building in the overall context of the project.

The scientists also valued the CCRP activities, stating that they learned from the participatory approach and regard it as successful in view of breeding outcomes and variety diffusion. Some (e.g. as plant breeders) said they gained expertise in seed issues, which was previously not in their remit. They acknowledged profiting from capacity building and cooperation with ICRISAT and farmer organizations. The “fiches techniques” (technical brochures on seed production) were highlighted as an important outcome, with the process of preparing brochures having been important as well. The scientists likewise appreciated that students were exposed to the collaborative approach in the field, a tact not otherwise practiced at universities in the region.

IER in Mali, for example, stated that the project improved the links between the national institutions and rural population as well as between IER and similar institutes in neighboring countries. This includes gaining not only formal contacts at an institutional level but also building trusting, reliable relations between the people involved, including, for example, the farmer organizations. The IER as an institution had gained credibility and reputation through the successful breeding and seed projects.

The Community of Practice meetings represent a framework for regular exchange among project partners. Scientists stated that participating in CoP meetings and exchange visits provided new inspiration and broadened their minds. Further, it is easier to contact people you have personally met, a benefit that could facilitate future cooperation. But inviting only three participants per project for a CoP meeting is hardly representative of the number of people involved. Given that some research institutes and farmer organizations are involved in several CCRP-funded projects, it is sometimes possible that more people from one organization participated in the meetings, which was seen as an advantage. Particularly scientists from INRAN, who appear to have scant funds for anything beyond business as usual, stated their gratitude for receiving project funds for traveling to such meetings. The time schedule of CoP meetings was perceived as being tight and demanding, and the monitoring and evaluation sessions somehow “artificial” or “intellectual.” One suggestion was to complement CoP meetings with more exchange visits within projects, the aim being to gain insights from assessing how activities are implemented practically in the various countries and localities.

Insights are limited regarding relations with other initiatives and projects, but the impression is that networking works well for knowledge exchange on conferences and also for training and capacity building, but less so for other fields of action, e.g. joint activities for seed marketing. Cooperation with other organizations beyond the project partners remains occasional and selective rather than systematic.

5 DISCUSSION OF RESULTS AND LESSONS LEARNED

The project convincingly demonstrates that farmer-managed seed production is feasible and not just at a local scale, and that the availability of seed facilitates variety adoption. In that these varieties produce higher yields under the region's variable and often adverse agroecological conditions, farmer-managed seed production contributes to food security and improved income, as was assumed in the theory of change.

This success is rooted in a number of conditions. Farmer-managed seed production started from the involvement of the farmer organizations in the breeding program and their active role in implementing decentralized participatory variety evaluation trials. Cooperation, therefore, was already established and members of the farmer organizations as well as other villagers had already gained knowledge and hands-on experience with the varieties. One of the first and important lessons to draw is that plant breeding, seed production, and variety adoption depend on each other. Investment in seed production can only succeed if relevant varieties are developed and farmers have had the opportunity to gain contextual knowledge about the varieties, enabling them to make informed decisions on their adoption. Success likewise depends on the seed value chain functioning in all its aspects.

The participatory approach allows for joint farmer-scientist learning in a real world situation: Based on their varietal choice, farmers work on their own land, in their own fields, and with the knowledge, values, and resources they have. Scientists learn by deepening their understanding of the context and incorporating it into their scientific models, approaches, and practical activities. Farmer organizations improve their skills for supporting and implementing emerging solutions and new options. Needs for capacity building are tied directly to the practical activities.

An important finding thus refers to the research design and methodology: Research seems best able to fulfill its function of stimulating innovation if it is fully involved on the ground. Doing so enhances collaboration and reduces the oft-complained about implementation gap. Additionally, the project relies on the state of knowledge available on innovation processes and seed system development, and has successfully incorporated this knowledge into activity design.

By working in the same range of agroecological conditions and under relatively similar socio-cultural conditions across several countries, it becomes possible to compare and evaluate results for their broader relevance, joining forces and capitalizing jointly on technical as well as socioeconomic outcomes. The close relations with other projects of MF, ICRISAT, and national research institutes in the target area further contribute to working together and enhancing impacts. The seed project is embedded in a number of related projects in which the same research and farmer organizations are partners. This allows integration and development of deeper insights into how the various projects and activities relate to each other, including activities focusing on nutrition, variety development, and soil fertility management.

Cooperating with other scientists in CCRP-funded projects can enhance capacities of these scientists and their team colleagues. Organizational change for these large and complex organizations is not likely expected from such project activities, as it would require that reflection on strategies and coordinated action happens *within* these organizations, involving various management levels. Senior researchers and research management staff change their models of implementation depending on their experiences, or what information is available to them. Hence, it could be worthwhile to design exchange meetings focused on the strategic management of research institutes in the region.

Building a regional Community of Practice that addresses the challenges of improving farming systems and their nutritional outcomes corresponds with the farmers' holistic approach, in which efforts to improve agricultural productivity are not divided into disciplines and where farming is closely related to household needs, e.g. nutritional and cash requirements.

Important multiplication effects also exist at the local level. Some farmer organizations receive two or three visits per month from individuals or other organizations searching for information relating to seed production. Farmers report that the training courses they received improve their farming practices in general and also to cooperate with "officials" on other topics or issues. The project activities have changed farmer awareness concerning the value of seed and its importance for improving production: Yield does not depend on soil fertility and rainfall alone, but also on the seed. The high visibility of the new varieties in the villages has effectively facilitated a multiplier effect, thus supporting adoption and project outreach.

Project partners acknowledge that women should share and play an important role in activities. The institutional culture the project partners created through their joint activities could contribute to more productive, diverse, equitable, and nutrition-sensitive farming systems.

The project perspective has evolved as researchers have learned more about women's changing roles concerning sorghum production, which was originally viewed as a men's crop. Sorghum used to be grown mainly on land managed by the head of the extended family; however, in some areas, women increasingly plant it, along with legumes traditionally planted by the women, on the individual fields allocated to them by the head. The women use these plots to supplement the dietary and cash needs of themselves and their children. These plots, though small in area compared to the total land used for sorghum production, can be nutritionally significant for women and young children, the most vulnerable groups for under- and malnutrition throughout West Africa. Note that the women do not grow sorghum for consumption alone; they are keen to sell parts of the harvest for cash. Rising sorghum prices have added to these incentives for women's engagement (see also Smale et al., 2014).

Insights into women's changing roles in sorghum production emerged from the participatory variety evaluation activities and have since influenced various other activities, including, for example, selection criteria applied in the breeding program. Involving women in seed project activities is also a result of this change in perspective.

It is with keen interest that women participate in variety evaluation and capacity building relating to seed production. The opportunity to participate in and profit from project activities is strongly related to the chance to access and control production assets (e.g. land, labor). As it is necessary to have a minimum access and control over resources to produce seed, this nearly automatically excludes women without access to land, as well as poor people with limited access to land and other relevant resources, from the benefits arising from seed production and marketing. The project has taken action to be inclusive at least for participation in variety evaluation, training, and other activities. Group-based activities could open up possibilities where individuals lack access to the necessary resources.

Heightened technical knowledge also helps women improve cultivation of other crops commonly grown by them. Women (and also men) farmers are interested in expanding the seed production to other crops that are important for their cropping systems, mainly legumes, groundnut, sesame, and vegetable seed. This step could be envisioned, provided that suitable varieties are available and can be tested and evaluated by farmers based on the experience gained for sorghum and pearl millet. The women were also interested in activities and capacity building relating to processing and marketing of food products such as flour, couscous, and *degué* (a sort of millet couscous). Women could participate in such activities without even having access to land.

A new rule for certified seed production that the minimum area be three hectares has excluded many women from seed production, as shown by records held by the farmer organizations. This is an example of how formal rules can be exclusionary and contribute to gender inequality with regard to women's and men's possibilities to seize emerging economic opportunities. A rule based on a minimum distance to other fields where different varieties are grown would have been less problematic.

Agricultural research projects that result in similarly tangible results for farmers are rare, and the project thus exemplary in showing how research can contribute to development outcomes. The basic conditions for the approach to be successful were found to be: 1) active involvement of relevant stakeholders, 2) a focus on tangible and relevant outcomes (e.g. yield, seed, food, income), and 3) effectively addressing important constraints (low yields, climate variability, poor soil fertility, low availability of cash, etc.).

The major landmarks achieved so far are the following: advancing from participatory variety evaluation to production of certified seed, with a focus on the technical feasibility and compliance with certification standards in the first phase; and, in the second phase, a focus on improving the organizational capacities and the marketing and dissemination activities.

For the marketing and dissemination activities, a number of challenges still need to be addressed. The real cost of sorghum and pearl millet seed production seems to not be fully known or calculable at present. The farmer organizations have received training courses on management and bookkeeping, but price-setting so far is not based on sufficiently clear criteria. During evaluation team visits, technical aspects of seed production were emphasized over marketing activities, even though many farmers see the latter as the major problem.

Local seed marketing to individual farmers is still weakly developed for the majority of farmer organizations and will require increased efforts to fully establish. It appears to be easier for organizations that sell mainly to their own members, such as UGCPA in Burkina Faso, and more difficult if a general market is to be addressed. A problem for some farmer organizations is that it takes a long time until their stock is sold and even longer until they receive the money.

Whereas technical support appears to be well developed, the support concerning organizational issues, finance, and marketing is not fully satisfactory. Technical advisors are fully integrated and close to the farmers and their organizations, but the same has not been achieved in other fields of action, e.g. marketing, financial, and legal.

There is also a lack of coordination between some of the actors along the seed chain. To reduce risks for farmer organizations, the critical junctures with other actors should receive more clear focus. These are 1) availability of source seed, 2) seed certification, and 3) the coordination between their own marketing and distribution pathways and those of government programs and NGOs.

The provision of source seed of preferred varieties was mentioned as a problem faced by farmer organizations mainly in Burkina Faso. The reasons could not be fully explored because a key person was unavailable at the time of the evaluation (see p. 38). Scientists from national research institutes in the other countries mentioned that the maintenance and storage of breeder seed, as well as production of source seed, is regarded as a weak point in the

"A good marketing strategy is based on knowing the varieties, appropriate packaging, timely distribution in close proximity to farmers, etc. We can expect from farmers that they adopt the new varieties only if we are able to master the whole system."

—Leader, farmer organization

seed chain. Lack of resources and equipment, currently being compensated for through cooperation with and coordination by ICRISAT, are problems to be addressed.

Seed certification rules, procedures, and costs can potentially be exclusionary, delay seed marketing, and reduce economic benefits. Seed certification largely worked, although farmers reported that certificates came in late in some cases and that the cost is relatively high, particularly for smaller seed lots. Apparently, seed producers not only have to pay a general fee but also the per diems of the people in charge of certification. It might be suggested that certification services reconsider the payment system in view of potential exclusionary or discriminating effects for small producers. This issue could also be addressed for the whole seed chain, e.g. in multi-stakeholder consultations (see below).

Furthermore, the seed distribution pathways that can be dealt with by the farmer organizations should be conceptualized within the framework of the Integrated Seed Sector Development (ISSD) approach. The parts covered by the farmer organizations and by government programs or aid organizations, respectively, need to be more clearly defined and their activities more effectively coordinated. Alternatives to the present distribution schemes (e.g. alternative payment via vouchers) should be explored. Also worthy of discussion is how beneficiaries of subsidized seed distribution schemes can access information on the varieties. Farmer organizations working as seed producers, distributing seed at a scale that is economically viable for them, could be effectively complemented through cooperation with government agencies and aid organizations, with positive effects on the distribution scale and poor farmers' access to seed.

The project is at an important turning point as it moves from the research stage toward broader implementation. New needs and challenges will arise: Where are the knowledge and capacity gaps and how can they be filled? Which material resources need to be mobilized? For example, farmer organizations may need to find ways to build reserve funds to help overcome payment delays, along with ways to claim their rights and strengthen their position in cases of payment defaults. The technical equipment for seed processing appears insufficient per the growth in volume. Not regarded a limiting factor initially, it is now perceived as an important bottleneck. In Dédougou (Burkina Faso), a facility with high flow capacity has been acquired with the help of a Canadian aid agency. In all other places the technical equipment lacks capacity and will need investment in order to further expand and professionalize activity. The same applies for storage facilities: Capacity limitations force farmer organizations to limit the number of seed producers and the amount of seed produced. The facilities are not always technically appropriate for seed storage over the long term.

Lack of material resources, unreliability of market partners, and distance to government services and institutions—typical constraints farmers and farmer-led seed enterprises face in developing countries—cannot be overcome by research and capacity building alone. But the most important challenge to sustainability is the high degree of dependency on *external factors* that cannot at present be controlled by the project partners.

Seed market conditions and their ability to function are strongly shaped not only by the market partners but by the political environment as well as institutional and administrative infrastructures that define the “room to maneuver” for those acting in these markets. Government structures are weak in many West African countries, which results not only in great complexity but also a lack of transparency and trust. Furthermore, the political actors in recent years seem to have strongly focused on the predominating rhetoric and approaches of private sector seed system development rather than taking a more integrated view as suggested by the ISSD approach. Together, this makes for a difficult environment for the emerging seed markets. Having not focused on these issues, the project clearly reaches limits here.

Two facts threaten the success of farmer-managed seed initiatives: 1) the necessary administrative infrastructure for variety registration and seed quality issues has yet to be fully developed to implement new seed legislation, and 2) general political instability exists in parts of the region. In Niger, for example, seed sector coordination was found to be extremely weak, resulting in low trust between various actors. The same problem exists in the other countries, although probably less pronounced. Establishing a seed production and marketing chain for high quality certified seed can only be sustainable if a degree of coordination, trust, and control can be guaranteed in a way that supports emerging seed marketing initiatives.

New seed legislation, if not implemented alongside considerable improvements in institutional structures and coordination, will probably not help the situation. A further risk is that, once functioning seed value chains are established, other players enter the market and compete with farmer organizations for the more profitable share of the market. It thus appears necessary to clearly define and address strengths and weaknesses of farmer-managed seed production (as summarized in Table 6) and also to build a political vision for a demand-driven seed market in which farmer organizations are active players and participate in the emerging value chains.

Table 6: SWOT matrix summarizing Strengths, Weaknesses, Opportunities, and Threats for the farmer-managed seed initiatives in Mali, Niger, and Burkina Faso. Strengths and weaknesses relate to internal factors, whereas opportunities and threats describe external factors

Strengths	Weaknesses
<ul style="list-style-type: none"> • Varieties with preferred traits and superior yield under farmers' conditions are developed • Participatory variety evaluation trials help farmers understand differences between varieties and make informed choices on variety use • Farmer organizations know technical requirements and certification procedures and how to comply with them • Seed production is technically well established • Farmers trust quality of seed produced by local farmer organizations • Seed production is economically attractive for farmers • Stakeholders along the seed chain know each other and their respective responsibilities • Farmer organizations focus on development of farming communities alongside profits from selling seed and are accountable to their members • Community of Practice approach strengthens ties and trust between project partners • Project partners share a vision for a seed system that serves farmers' needs and creates value in the farming sector 	<ul style="list-style-type: none"> • Local seed marketing is still difficult due to moderate or slowly growing and fluctuating demand • Lack of coordination with seed distribution schemes of aid organizations and state agencies; information flow to end users is not well established for this distribution pathway • National research institutes lack own resources to maintain varieties and provide source seed of farmer-preferred varieties (may be to varying degree) • Government control institutions lack capacity and resources (e.g. timely delivery of seed certification approval not guaranteed, certification cost high for farmers) • Processing and storage facilities available to farmer organizations are insufficient and require investment if seed volume grows • Farmer organizations lack capacity with regard to marketing, financial, and legal issues • Financial reserve and liquidity of farmer organizations is limited (e.g. in case of delayed payment)

Opportunities	Threats
<ul style="list-style-type: none"> • Market potential exists for improved varieties adapted to key constraints of the region • High interest internationally in building more sustainable, equitable, and resilient seed systems • Expertise in Integrated Seed Sector Development (ISSD) is available • Governments of West African countries have signed the CBD and ITPGRFA • Governments of West African countries are committed to the Right to Food • Harmonization of seed laws could facilitate regional cooperation if fully implemented 	<ul style="list-style-type: none"> • New seed legislation is driven by commercial interests promoted by powerful players instead of balancing diverging interests • Weakness or absence of functioning institutions for implementation of new seed law could cause uncertainty and lack of transparency • New seed legislation could limit legal spaces for informal seed transactions (Farmers' Rights) • Conditions in the market (e.g. reliability of market partners, execution of law) are not generally favorable for farmer organizations (e.g. in case of payment defaults) • Once the formal seed market is established, large commercial enterprises could compete with farmer organizations

External factors play important roles for the project success. Sustainability is the weakest aspect of the project despite the success and positive outcomes achieved so far. The risk of failure remains high if the original focus on variety development and seed production is not expanded. Farmers could, in the worst of cases, abandon seed production in spite of the technical and organizational knowledge they have gained.

Focusing on the technical feasibility of tying variety development to seed markets suggests a project implemented by a breeding program and its partners, initially because such activities are close to their original mandate (developing varieties that are adopted by farmers), but also because it could be a successful development strategy in spite of seed being a highly politicized issue (see Section 4.1). In order to implement the approach on a broad scale and with probably less external support in the future, external factors must be taken into account and strategies actively built to reduce the risks for farmer organizations.

The project weaknesses were not so much in what was done or how; rather, in the issues not or insufficiently addressed, including the political and administrative environment, the coordination of some actors along the seed chain, and the lack of access to material resources needed to make the project more sustainable and secure its achievements.

“What is needed is a political will in all West African countries that this farmer seed production as part of the seed system should make good progress.”

—Scientist

6 RECOMMENDATIONS

At this point, McKnight Foundation funding and support should neither be withdrawn nor reduced but continued in order to strategically address the issues that, despite the project's numerous and convincing achievements, threaten its sustainability.

A possible next phase could address the existing challenges while moving beyond the project's original focus on research, breeding, and seed production. New types of activities should be envisioned that more holistically target the development of the seed sector.

The essential challenges in the seed value chain should be addressed right away. The project's main focus so far has been on developing methodologies and capacity building for successful implementation of farmer-managed seed production. Knowledge and capacities are important for achieving significant change, but they need to be complemented in order to result in sustainable outcomes. The importance of increasing material resources (besides knowledge) should not be undervalued. Therefore, capacity building should be strengthened, particularly for post-harvest, management, and financial issues (full cost accounting, pricing, marketing, networking, etc.), and be accompanied by organizing support to investment, and building up protection funds and other risk-reducing instruments. This may require improved or more clearly defined strategic partnerships with other initiatives. Moreover, professionally developed publicity, i.e. via radio broadcasts with important people and farmers making a case for farmer-produced high quality seed, could help stimulate and scale up demand, improving the visibility of farmer organizations as providers of high quality seed.

Coordination should be improved, especially among the connecting points in the seed value chain where activities of farmer organizations depend on other people's actions. These are 1) provision of source seed, 2) seed certification procedures, and 3) seed distribution activities of government agencies and aid organizations.

Conducting policy and stakeholder analyses prior to initiating activities that target the seed sector as a whole are suggested. A policy analysis of the ECOWAS seed legislation and national seed laws in all three countries (Mali, Niger, and Burkina Faso) should focus on the coherence of the seed legislation with international commitments in order to identify entry points for a science-policy dialogue.

The international agreements signed by the West African countries could provide such entry points. The work should also focus on the ongoing processes for building institutions and defining rules for their implementation. Moreover, the policy analysis should describe the possibilities for civil society actors (NGOs, farmer organizations) and researchers participation, and list the important steps taken and decisions made in the process. On this basis, the involved organizations could develop a strategy for a policy-science and/or policy-civil society dialogue (see below). Researchers and farmer organizations could also develop policy briefs, invite consultations, or join consultations organized by strategic partners (see next paragraph).

Furthermore, a stakeholder analysis could be conducted to gain insights into power relations, resources, and interests that may guide diverse actors' strategies and help build strategic alliances. Some of this knowledge will be present with individuals involved in the project, but it probably has not been systematically compiled and analyzed. The German Development Cooperation agency GIZ, for example, has developed a practice-oriented approach to stakeholder analysis consisting of ten building blocks that can be applied independently. They include classical stakeholder analysis tools such as mapping of power and interest groups, but also force field analysis, or the identification of veto players without whose explicit consent the project cannot be successfully implemented (Zimmermann & Maennling, 2007).

Stakeholder dialogue could take the form of national Cadres de Reflexion (or multi-stakeholder platforms) that work jointly toward strengthening and coordinating the sector. Each country should have strategic planning workshops performed in which government agencies, other donors, organizations, and projects are involved, the goal being to define weaknesses and existing bottlenecks and then take joint actions to address them.

The ISSD framework could be helpful in this regard, as it avoids heating up the political debate by acknowledging that diverse interests exist and that activities driven by these diverging interests can lead to different types of useful contributions to seed system development. The framework could also be used to better understand the different priorities of the various project partners, particularly the farmer organizations that take a sort of intermediate position, as they share public interest with the breeding programs. Their opportunities to act are limited to activities that are economically viable for the organizations and their members.

The project should further address the need for a science-policy dialogue, e.g. in the form of written policy briefs and/or science-policy consultations that involve other stakeholders. Scenario analysis has been successfully applied as a tool for such dialogue in other projects. Here, it could help stakeholders arrive at a shared vision of how the seed sector in their country should look fifteen to twenty years from now and the roles government institutions, farmer organizations, and other enterprises could play to arrive at more sustainable, equitable, and resilient seed systems. Farmer organizations should engage in civil society consultations that may be part of the political process and jointly work out a strategy for it. In Burkina Faso, for instance, such consultations exist already (R. Kaboré, pers. comm.).

National research institutions should play an active role in a possible third phase. Variety registration and maintenance of breeder seed and source seed provision are important for effective continuing transfer of innovations from breeding programs into practice. Existing obstacles should be urgently addressed and removed where possible. Among the research needs stated by participants: improving storability of (some) new sweet sorghum varieties and testing varieties for performance in other locations. However, instead of just expanding project activities to other locations, efforts should be directed toward institutionalizing the approach as far as possible. Besides climate variability, soil fertility management seems to be a key issue throughout the region. The integrated approach taken by building a West Africa Community of Practice is promising and should be continued.

For ICRISAT, the disharmony between its own funding requirements (“full cost recovery”) and McKnight’s funding strategy is an obstacle. On the other hand, experience shows that ICRISAT needs qualified partners exactly for bridging the implementation gap. For ICRISAT, as well as the national research institutes, a lot of reputation can be gained and impact from breeding programs secured if the delivery of seed is ensured long-term and in a sustainable manner. It is a shared interest to jointly resolve existing problems by effectively combining funds from different sources.

The overall approach developed in the CCRP in general and the West Africa Community of Practice in particular are, for McKnight, important contributions toward developing problem-oriented and transformative research capacities. Based on participant statements, a need for adjustments could be identified in the Monitoring and Evaluation (M&E) activities. That said, only a few respondents made critical remarks and it is difficult to make recommendations, given the lack of insight into how M&E is actually applied. The focus of any possible adjustment should be on facilitating learning and reflection for project actors. It was suggested that CoP meetings could be complemented by on-site exchange visits. To facilitate organizational learning, partner organizations’ senior research and research management staff could be invited to join a reflection on project achievements and the conditions and approaches on which they are based. Box 3 summarizes these main recommendations.

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BOX 3: SUMMARY OF RECOMMENDATIONS

- Seed value chain
 - Address remaining challenges, particularly with regard to seed marketing and financial risk reduction
 - Improve coordination, particularly with regard to source seed provisioning, seed certification, and complementary seed distribution channels to end users
- Policy analysis
 - Assess ECOWAS seed legislation and national seed legislations with regard to their coherence with international commitments (CBD; ITPGRFA; Right to Food) and the legal space for seed provisioning on-farm and farmer-to-farmer seed transactions
 - Assess ongoing processes and possible entry points for science-policy dialogue
- Stakeholder analysis
 - Conduct a stakeholder analysis in order to build strategic alliances
 - Organize multi-stakeholder dialogue
 - Scenario analysis for seed sector development
- Integrated Seed Sector Development
 - Use the framework to fully conceptualize the project within ISSD, particularly the differences and complementarities between public and private sector interests and the role of the partner organizations and farmer-managed seed value chains within the framework
- Research organizations
 - Continue integrative approaches (breeding, variety evaluation, crop and soil fertility management)
 - Institutionalize decentralized, farmer-managed, and participatory variety evaluation
 - Resolve disharmonies in funding strategies and requirements by combining funds from various sources
- Farmer organizations
 - Engage in policy dialogue and build strategic alliances
 - Reduce risks, e.g. financial
 - Identify possibilities for improving the material resource basis, e.g. investment in seed storage and processing facilities where necessary
- McKnight Foundation
 - Continue project funding and support
 - Adapt M&E procedure in a way that better serves project actors
 - Complement CoP meetings with exchange visits and learning from practical implementation
 - Enhance visibility of project achievements for partner organizations' senior research and research management staff

ANNEX

A. PERSONS AND ORGANIZATIONS VISITED, FEBRUARY 1-16, 2014

Date	Location	Person/Organization	Comment
Mali			
February 1	Bamako	<ul style="list-style-type: none"> Gottfried Horneber 	Arrival
February 2	Bamako	<ul style="list-style-type: none"> Eva Weltzien, ICRISAT Marthe Diarra Gottfried Horneber and Marthe Diarra Melinda Smale, researcher (impact study) 	Planning and interview Arrival Team building session Interview
February 3	Siby Bamako	<ul style="list-style-type: none"> Mamadou Coulibaly, technical advisor AOPP Farmer group of COOPROSEM (seven men, one woman) Women association Njeleni (fourteen women) Mamadou Coulibaly Team Eva Weltzien "Africa Rising" meeting 	Interview Focus group interview Focus group interview Continuation interview Team wrap-up Feedback Dinner with "Africa Rising"
February 4	Dioila	<ul style="list-style-type: none"> Daouda Traoré, president ULPC and Yalaly Traoré, field advisor ULPC Team 	Interview Visit to ULPC field activities Team session
February 5	Magnabougou Wacoro Dioila	<ul style="list-style-type: none"> Farmer seed cooperative (thirteen men, six women) Delegates of three seed cooperatives (ten men) Yalali Traoré Team 	Interview Interview Continuation interview Team wrap-up
February 6	Bamako	<ul style="list-style-type: none"> Mamourou Diourté, Abdoulaye Diallo, Abocar Omar Touré, Bocar Diallo (IER, director and staff of sorghum breeding program) Amadou Sidibé (IER, genetic resources responsible) Eva Weltzien and Fred Rattunde (ICRISAT) 	Interview Interview Interview
February 7		<ul style="list-style-type: none"> Melinda Smale (researcher) 	Interview
		<ul style="list-style-type: none"> Mamourou Sidibé (ICRISAT, field assistant) 	Interview

Date	Location	Person/Organization	Comment
		<ul style="list-style-type: none"> Oumar Coumaré (AOPP, responsible for seed activities) 	Interview
		<ul style="list-style-type: none"> Issa Coulibaly (AOPP, coordinator) 	Interview
		<ul style="list-style-type: none"> Harouna Sangaré (Malimark A2F (AGRA)) 	Interview
Burkina Faso			
	Ouagadougou	<ul style="list-style-type: none"> Team 	Arrival Summary of findings Mali Preparation of fieldwork Burkina Faso
February 8	Kaya Zikiémé Ouagadougou	<ul style="list-style-type: none"> Roger Kaboré (AMSP, president) and delegates of three seed producer groups (twelve men, one woman) Roger Kaboré and three technical advisors of AMSP Seed producer group (sixteen men, seven women) Team 	Interview Visit to a seed shop Interview Interview Visit to storage facilities Back to Ouagadougou Team wrap-up
February 9	Ouagadougou Dédougou Ouagadougou	<ul style="list-style-type: none"> Hamado Tapsoba, (McKnight Foundation, regional representative) Nonyeza Bonzi (UGCPA, president), Adama Sidibé and Yehoun Romaric (UGCPA, technical advisors) Yehoun Romaric Two technical advisors and nine seed producers of UGCPA (nine men) Nonyeza Bonzi (UGCPA, president) Team 	Interview Planning and interview Visit to UGCPA storage facilities Focus group interviews (separately for producers and advisors) Interview Team wrap-up
February 11	Ouagadougou	<ul style="list-style-type: none"> Mr. Iliboundo (Chamber of Agriculture) Abdoulaye Semde (National Seed Service) Flavienne Ouandaogo and Shaka Adindji (national farmer association) Assita Ouédraogo (UNPS-B) Team 	Interview Interview Interview Interview Summary of findings Burkina Faso
Niger			

B. SKYPE AND PERSONAL INTERVIEWS

Bettina Haussmann, February 6, 2014

Eva Weltzien-Rattunde, ICRISAT, January 30 and February 13, 2014

Kirsten vom Brocke, CIRAD, February 11, 2014

C. EMAIL CORRESPONDENCE AND QUESTIONNAIRES

Dr. Abocar Touré, IER, Bamako, Mali

Mr. Ali Maman Aminou, director, Fuma Gaskya, Niamey, Niger

Mr. Yacouba Tanda, agricultural extensionist, Farmer Union “ MADDABEN”/Mooriben, Falwel, Niger

Mr. Amadou Moussa Abdoulaye, executive secretary, Farmer Union “ Mooriben” Niamey, Niger

Mr. Sidibé, Adama, sorghum extensionist, UGCPA, Dédougou, Burkina Faso

Mr. Roger Kaboré, agronomist, president and extensionist, AMSP, Kaya, Burkina Faso

Mr. Yalaly Traoré, cereal extensionist, ULPC, Dioila, Mali

COOPROSEM, administrative committee, Siby, Mali

HAREYBEN, extension group, Téra, Niger

D. GENERAL DOCUMENTS USED FOR THE EVALUATION

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Diallo, M. (no year) Ph.D. Thesis (unpublished)

Project reports, presentations CoP meetings

Reports, presentations provided by farmer organizations

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Gottfried Horneber studied agronomy with a focus on crop production and farming systems in the tropics and subtropics. He has worked as a consultant for more than 15 years, gaining expertise in participatory approaches and sustainable farming practices in rural development and gender issues and in relation to adaptation to climate change in Africa. He is associate consultant of FAKT Consult for Management, Training and Technologies, an organization with more than twenty-five years of project evaluation and capacity building experience. <http://www.fakt-consult.de/users/gottfried-horneber>

ABOUT THE McKNIGHT FOUNDATION

The McKnight Foundation, a Minnesota-based family foundation, seeks to improve the quality of life for present and future generations. Through grantmaking, collaboration, and encouragement of strategic policy reform, we use our resources to attend, unite, and empower those we serve. Program interests include regional economic and community development, Minnesota's arts and artists, early literacy, youth development, Midwest climate and energy, Mississippi River water quality, neuroscience, international crop research, and community-building in Southeast Asia. Our primary geographic focus is the state of Minnesota, with significant support also directed to strategies throughout the U.S. and in Africa, Southeast Asia, and Latin America.

Founded in 1953 and endowed by William and Maude McKnight, the Minnesota-based Foundation had assets of approximately \$2 billion and granted about \$86 million in 2013. In 2013, McKnight invested \$6 million, or about 7% of total grantmaking, in efforts to explore solutions for sustainable, local food systems through the Collaborative Crop Research Program.

