



zef

Center for
Development Research
University of Bonn

Final Project Report

ANJA CHRISTINCK, FRED RATTUNDE, ALPHA KERGNA, WELLINGTON MULINGE AND EVA WELTZIEN

“YOU CAN’T GROW ALONE” -

PRIORITIZED SUSTAINABLE SEED SYSTEM DEVELOPMENT

OPTIONS FOR STABLE FOOD CROPS IN SUB-SAHARAN AFRICA:

CASES OF KENYA AND MALI

Published by:

Zentrum für Entwicklungsforschung (Center for Development Research)
Genscherallee 3
D- 53113 Bonn
Germany

Phone: +49-228-73-1861

Fax: +49-228-73-1869

E-Mail: presse.zef@uni-bonn.de

www.zef.de

PARI (Program of Accompanying Research for Agricultural Innovation): www.research4agrinnovation.org

Contact addresses:

Anja Christinck (PhD)

Senior Scientist

German Institute for Tropical and Subtropical Agriculture (DITSL)

Steinstr. 19, 37213 Witzenhausen, Germany

E-mail: a.christinck@ditls.org

Fred Rattunde (PhD)

Honorary Fellow

Agronomy Department, University of Wisconsin-Madison

1575 Linden Drive, Madison, WI 53706, USA

E-mail: f.rattunde@gmail.com

Alpha Oumar Kergna (PhD)

Agroéconomiste

Programme Économie des Filières (Ecofil), Institut d'Économie Rurale (IER)

B.P.258, Bamako, Mali

E-mail : a.kergna@yahoo.fr

Wellington Mulinge (PhD)

Senior Principal Research Officer

Socio-Economics and Policy Development, Kenya Agricultural and Livestock Research Organisation (KALRO)

KALRO Headquarters, Kaptagat Road, Off Wayaki Way

P.O. Box 57811, 00200 Nairobi, Kenya

E-mail: wellington.mulinge@kalro.org

Eva Weltzien (PhD)

Honorary Fellow

Agronomy Department, University of Wisconsin-Madison

1575 Linden Drive, Madison, WI 53706, USA

E-mail: eva.weltzien@gmail.com

TABLE OF CONTENTS

List of Tables.....	III
List of Maps and Figures	III
Abbreviations and Acronyms	IV
Summary	1
Résumé.....	5
1 Introduction and Background	10
2 Study Objectives.....	10
3 Approach and Methodology	11
3.1 Basic Concepts and Issues	11
3.2 Methodology Used.....	19
4 Results of Kenya Case Study: Economic and Regulatory Framework, Actor Perspectives and Priorities for Sustainable Seed System Development.....	32
4.1 Economic and Regulatory Framework for Seed System Development in Kenya	32
4.2 Results From Interviews With Individual Seed System Actors in Kenya	41
4.3 Workshop Results: Priority Options for Seed System Development in Kenya	58
5 Results of Mali Case Study: Economic and Regulatory Framework, Actor Perspectives and Priorities for Sustainable Seed System Development.....	62
5.1 Economic and Regulatory Framework for Seed System Development in Mali.....	62
5.2 Results From Interviews With Individual Seed System Actors in Mali	69
5.3 Workshop Results: Priority Options for Seed System Development in Mali.....	87
6 Discussion of Results	91
6.1 Seed Quality	92
6.2 Seed Availability at the Right Time and Place.....	96
6.3 Seed Access	105
6.4 Cross-Cutting Issues	110
6.5 Reflection on Methodology and Results Obtained	115
7 Conclusions and Entry Points for Seed System Improvement	117
7.1 Actor Orientation: A Vital and Complementary Perspective for Seed System Development.....	117
7.2 "Farmer First" – A Necessary Perspective.....	118
7.3 Improved Collection and Sharing of Varietal Information and Performance Data	118
7.4 Strengthening Farmer Cooperatives and Their Networks.....	119
7.5 Integrate Plant Breeding as Part of Seed System Development	120
7.6 Moving Resources From Control and Relief to Creativity and Resilience	121
7.7 Concluding Remarks.....	122
Acknowledgements.....	124

About the Authors.....	125
About DITSL.....	125
References	126
Annex	135
A. Complete List of Interviews Conducted in Kenya, 7-24 February 2017	136
B. Complete List of Interviews Conducted in Mali, 1-21 March 2017	142
C. List of Workshop Participants in Kenya.....	150
D. List of Workshop Participants in Mali.....	151
E. Specific Suggestions for Seed System Enhancement by Crop and Country	153

LIST OF TABLES

- Table 1:** The study areas and their relative expected levels of ‘modern’ maize and sorghum variety adoption in Kenya.
- Table 2:** The study areas and their relative expected levels of ‘modern’ maize, sorghum, pearl millet and rice variety adoption in Mali.
- Table 3:** Number of interviews conducted by study region in Mali and Kenya.
- Table 4:** Number of interviews conducted by actor category in Kenya and Mali.
- Table 5:** Amounts of locally produced and imported certified seed available in Kenya for the period 2006/ 2007 to 2016/2017
- Table 6:** Grain and seed prices stated in interviews and seed-to-grain-price ratios for maize hybrids and sorghum OPVs in Kenya in February 2017
- Table 7:** Priority actions for seed system improvement identified by workshop participants from three groups of seed system actors in Kenya.
- Table 8:** Cultivated area, recommended seed rates, estimated total amounts of seed required for sowing and amounts of certified seed available for sorghum, pearl millet, maize and rice crops in Mali.
- Table 9:** Grain and seed prices stated in interviews (in FCFA, 1 US-\$ = 556 FCFA) and seed-to-grain price ratios for various crops and variety types in Mali, March 2017.
- Table 10:** Three highest-ranked options for improving the availability of seeds in proximity to farmers identified in each group discussion.
- Table 11:** Three highest-ranked options for enhancing adoption of improved seeds by farmers identified in each crop-based discussion group.
- Table 12:** Comparisons of major seed business types operating in Mali and Kenya for their engagements in basic seed system functions
- Table 13:** Assessments of comparative advantages and key challenges for major seed businesses types for achieving seed availability for smallholder farmers (women and men) in Kenya and Mali.

LIST OF MAPS AND FIGURES

- Figure 1:** Basic seed system functions, embedded in larger socio-cultural and agroecological contexts.
- Figure 2:** SECI model for innovation, including the four steps of Socialization, Externalization, Combination and Internalization.
- Figure 3:** Geographic situation of selected study countries, Kenya and Mali.
- Figure 4:** Study locations in Kenya with mean annual rainfall isohyets in mm.
- Figure 5:** Study locations in Mali with mean annual rainfall isohyets in mm.
- Figure 6:** Actor categories identified for selection of interview partners, based on their activities in relation to seed system functions.
- Figure 7:** Quantities of grain imports (maize, rice, wheat, sorghum) in Kenya, 2003-2013.
- Figure 8:** Options for sustainable seed system development in Kenya in order of preference (from top to bottom), prioritized across all workshop participants.
- Figure 9:** Quantities of grain imports (maize, rice, wheat) in Mali, 2003-2013.
- Figure 10:** Options for sustainable seed system development in Mali in order of preference (from top to bottom), prioritized across all workshop participants.

ABBREVIATIONS AND ACRONYMS

AATF	African Agricultural Technology Foundation
ADC	Agricultural Development Corporation (Kenya)
AFC	Agricultural Finance Corporation (Kenya)
AfricaRice	Africa Rice Center
AGRA	Alliance for a Green Revolution in Africa
AMEDD	Association Malienne d'Éveil au Développement Durable (Mali)
ARIPO	African Intellectual Property Organization
ASDS	Agricultural Sector Development Strategy (Kenya)
ASSEMA	Association des Semenciers du Mali
BMGF	Bill & Melinda Gates Foundation
BMZ	German Federal Ministry for Economic Cooperation and Development
CAADP	Comprehensive Africa Agriculture Development Programme
CBD	Convention on Biological Diversity
CCRP	Collaborative Crop Research Program
CICR	Comité International de la Croix Rouge (Mali)
CIMMYT	International Maize and Wheat Improvement Center
CMDT	Compagnie Malienne pour de Développement du Textile
CNSOV	Comité National des Semences d'Origine Végétal (Mali)
COMESA	Common Market for Eastern and Southern Africa
CRS	Catholic Relief Service
CSA	Commissariat à la Sécurité Alimentaire (Mali)
DSD	Direct Seed Distribution (Kenya)
DUS	Distinctiveness, Uniformity and Stability
EAC	East African Community
EGS	Early Generation Seed
ERSWEC	Economic Recovery Strategy for Wealth and Employment Creation (Kenya)
FAO	Food and Agriculture Organization of the United Nations
FIPS	Farm Input Promotions Africa
GDP	Gross Domestic Product
GeRRI	Genetic Resources Research Institute (Kenya)
GIE	Groupe d'Intérêt Économique (Mali)
GMO	Genetically Modified Organism
GNI	Gross National Income
GPS	Global Positioning System
HDI	Human Development Index
IER	Institut d'Économie Rurale (Mali)
ICARDA	International Center for Agricultural Research in the Dry Areas
ICESCR	International Covenant on Economic, Social and Cultural Rights
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
INSAH	Institut du Sahel
IITA	International Institute of Tropical Agriculture
IRRI	International Rice Research Institute
ISTA	International Seed Testing Association
IT	Information Technology
ITPGRFA	International Treaty on Plant Genetic Resources for Food and Agriculture
KALRO	Kenya Agricultural and Livestock Research Organization
KCEP	Kenya Cereal Enhancement Programme
KENAFF	Kenya National Farmers' Federation
KENFAP	Kenya National Federation of Agricultural Producers
KEPHIS	Kenya Plant Health Inspectorate Service
KFA	Kenya Farmers Association
KSC	Kenya Seed Company
a.s.l.	Above sea level

MET	Multi-Environmental Trial
MLN	Maize Lethal Necrosis
MoALF	Ministry of Agriculture, Livestock and Fisheries (Kenya)
NAIAAP	National Agricultural Input Accelerated Access Programme (Kenya)
NASEP	National Agricultural Sector Extension Policy (Kenya)
NARI	National Agricultural Research Institute
NARS	National Agricultural Research System
NBA	National Biosafety Authority (Kenya)
NEPAD	New Partnership for Africa's Development
NERICA	New Rice for Africa
NGO	Non-Government Organization
NPT	National Performance Trial
NPTC	National Performance Trials Committee
NVRC	National Variety Release Committee
OECD	Organisation for Economic Co-operation and Development
ON	Office du Niger (Mali)
OPV	Open-pollinated variety
PARI	Program of Accompanying Research for Agricultural Innovation
QDS	Quality Declared Seed
RIDEP	Rural Initiative Development Programme (Kenya)
SECI	Socialization, Externalization, Combination, Internalization
SEWOH	Sonderinitiative EINEWELT ohne Hunger ('One World, No Hunger')
SMTA	Standard Material Transfer Agreement
SRI	System of Rice Intensification
STAK	Seed Trade Association of Kenya
UPOV	International Union for the Protection of New Plant Varieties
USA	United States of America
USAID	United States Agency for International Development
VCU	Value for Cultivation and Use
WAAPP	Western African Agricultural Productivity Promotion
WASP	West Africa Seed Program
WECARD	West and Central Africa Council for Agricultural Research and Development
WFP	World Food Program

SUMMARY

Introduction and Objectives

Seed is a vital entry point for enhancing value and productivity in agriculture, and is therefore the focus of many agricultural policies and interventions in Africa. However, there is an ongoing debate on the benefits of such seed system interventions, particularly for small-scale farmers.

The overall purpose of this study was to propose an agenda for supporting sustainable development of seed systems in two Sub-Saharan countries in Africa: Kenya and Mali. This agenda is to be based on the experiences and insights of seed system actors contributing to various seed system functions and operating at different scales. The study was commissioned to contribute to the Program of Accompanying Research for Agricultural Innovation (PARI)¹, which is a component of the German Government's 'One World, No Hunger' (SEWOH) initiative.

The study focused on staple cereal crops, including maize and sorghum in Kenya and maize, rice, sorghum and pearl millet in Mali. The specific study objectives were:

- To compile information about the current context of seed system functioning, including basic economic information, policies and legal frameworks, for each country and staple cereal crop considered;
- To identify constraints and opportunities for enhancing seed system dynamics, based on the insights and capacities of diverse actors in each country; and
- To propose an agenda for targeted capacity building and strengthening of the collaborative process of seed system innovation for each country.

Approach and Methodology

Seed systems are conceptualized in this study as human activity systems that are established and maintained by actors, i.e. the people who pursue individual and collective purposes related to seed. The collective purpose of a seed system is to provide farmers with high quality seeds of an appropriate range of varieties and crops in sufficient quantity, at an affordable price, and in a timely manner. Basic seed system functions considered include appropriate legal frameworks, variety development, seed supply, and dissemination of seed. The value for crop production and use created by using quality seed is considered to be an integral system component.

Innovations in complex systems, such as seed systems, require changes in the actors' individual capabilities as well as their relationships that facilitate integration and application of knowledge from various sources. Establishing dialogue among seed system actors and setting priorities based on collective insights can thus be a starting point for innovation.

The approach used in this study was to combine a review of secondary sources with qualitative assessment of actor perspectives using semi-structured interviews with individuals and small groups. Study areas were chosen to represent contrasting levels of adoption of 'improved' varieties and different agroecological conditions for each country and crop. The study areas chosen in Kenya were Trans Nzoia, Homabay and Tharaka Nithi Counties. In Mali, the Sikasso, Ségou and Mopti Regions, including the irrigated rice area of Niono, were targeted.

Interviewees from different actor categories were sought, including genetic resources specialists, plant breeders, seed producers, seed sellers, extension agents, farmers, grain traders and processors, as well as other support actors, such as government agency and non-governmental organization (NGO) staff. Care was taken to include

¹ <http://research4agrinnovation.org>

Summary

actors operating at smaller and larger scales and to include women as well as men (particularly for farmers, grain traders and grain processors).

A total of 119 interviews with 222 participants were conducted in Kenya from 7 to 24 February 2017. In Mali, 163 interviews with 233 participants were conducted from 1 to 21 March 2017. Furthermore, stakeholder workshops were conducted to bring together a broad range of actors for joint discussion and prioritization of proposed seed system development options in each country. The results of interviews were synthesized according to seed system functions, differentiated by actor categories. The results of workshops were presented separately.

Results and discussion

Both countries have ample unrealized potential for production of the staple cereals targeted in this study yet they still are not completely self-sufficient. Staple grain imports are substantial, totaling 1.6 million tons in Kenya (wheat, rice, maize and sorghum) and 0.3 million tons in Mali (rice and wheat) in 2013. Agricultural policies and strategies in both countries target increased agricultural production and both seek to strengthen their agricultural sectors by implementing measures to increase the use of commercial certified seed; these measures also included free distribution of seed to farmers.

Foreign as well as domestic private seed companies are active in Kenya, and their number has increased over the past 20 years. This is due, in part, to the importance of maize in Kenya, and the presence of large commercial farms as well as small-scale farmers. However, private seed companies in Kenya, with one exception, usually do not run their own breeding programs, but arrange for seed production and marketing of varieties developed by public breeding programs or that were introduced from other countries and released in Kenya. The Kenyan certified seed sector is dominated by one large parastatal company, the Kenya Seed Company (KSC), holding a market share of 70–80%. Private sector companies, including local, regional and multinational ones, share the remaining market. For sorghum and maize, certified seed accounts for approximately 30% and 60% of the total area sown, respectively, with some variation between study areas.

Mali, in contrast, has no private breeding companies, but partnerships between public breeding programs and farmer cooperatives are common. Farmer seed-producer cooperatives are major producers and sellers of commercial seed in Mali, with most cooperative members being small-scale farmers themselves. Other commercial seed companies purchase certified seed from these same seed-producer cooperatives for marketing in peri-urban areas, or to NGOs and other projects for further distribution. Certified seed is currently used on about 5% of the total area sown with sorghum and pearl millet, and 10–15% for maize and irrigated rice crops. However, the share is higher in some 'high potential' production areas, and lower in drier areas of northern Mali. Farmers' interest in new varieties is high and the commercial seed market is growing dynamically, particularly for sorghum and pearl millet.

The results from interviews with seed system actors are presented in the study in relation to seed system functions and discussed for contributions to the three dimensions of seed system security, which entail quality, availability and access to seed. **Seed quality** issues entail the needs for adaptation to production and storage conditions and the value for specific uses. Farmers indicated that several features other than, or in combination with, yield *per se* guide their choice of varieties, e.g. adaptation to local production conditions, and quality traits relating to post-harvest processing or specific uses. Both grain quality and adaptation to low soil fertility were predominantly issues of concern for small-scale farmers, both men, and particularly women. Hence, more attention to differentiated user preferences and gender issues appear to offer great potential for seed system innovation.

Diversity is another important issue that is linked to quality as well as availability of seed. Thus, for modern seed systems to support farmers' strategic use of varietal diversity, they need to provide varieties that match the range of production conditions and objectives that guide farmer decisions in a particular context, and to be responsive to new challenges and opportunities. Legal frameworks that tend to restrict the type of varieties that

can enter the market and slow down the time for new varieties to reach farmers' fields are not particularly supportive in this regard, and options should be explored to use or extend the legal space for seed systems to increase, rather than limit, the diversity of varietal options that are available to farmers.

In Kenya, many farmers experienced low seed germination in commercial seed in spite of strict quality requirements and control mechanisms. Seed quality problems were less frequently mentioned in Mali. Ensuring the quality of commercial seed is thus an issue that requires attention, as it increases production risks and undermines trust among actors, which is an essential requirement for effective seed system functioning.

Seed availability is the outcome of many different functions that contribute to seed of desired varieties being available in sufficient quantities within reasonable proximity and in a timely manner. The availability of seed *per se* was not a serious problem, as seed quantities were generally sufficient for all crops studied in Kenya and Mali. However, there were cases where the preferred variety or hybrid was not available, causing farmers to switch to one that was less preferred. Contributing factors mentioned included insufficiency of early generation seed, delays due to the certification process, lack of coordination among actors, and seed companies or seed sellers choosing to first sell seed of less preferred varieties, due to commercial interests.

The slow turnover of varieties offered to farmers in both countries suggests difficulties in getting new improved varieties onto the market. Public breeders in both countries highlighted the constraints caused by limited funds and dependence on short-term project grants. Delays caused by the variety release process were also mentioned. Several models of collaboration between public and private sector partners, as well as in some cases third parties, are presented and discussed as options to overcome some of these constraints. These models range from public breeding programs partnering with farmer-managed seed enterprises, to temporary collaboration of private and public breeding organizations, and also include various models of interested parties raising funds for public breeding research to address their demands.

Closer examination of opportunities to strengthen farmer seed-cooperatives in their collaboration with other seed system actors could identify cost-efficient options for enhancing availability of improved varieties, especially for specific user groups, target crops or agroecologies that are too small as a market for other private breeding companies to focus on. Furthermore, alternative options to include new types of actors, e.g. grain traders, in seed dissemination could be explored in areas where a network of seed selling points is not fully developed.

Farmers' ability to **access seed** even when it was physically present was also raised as an issue. Even though seed appears to be relatively inexpensive in both Kenya and Mali, having the cash at hand when wanting to buy seed can be problematic for certain user groups. These problems of seed access need to be discussed against the background that seed in traditional farmer-managed systems has low monetary, but high 'social value', resulting in a situation where seed is always accessible, even in difficult situations. Options for overcoming cash availability and cash flow constraints that contribute to limiting access to seed are presented and discussed, with particular attention being given to various forms of value-chain financing encountered in the course of the study.

Free seed distributions is an issue of continuing importance in Kenya and recently so in Mali. Although they are apparently justified by the assumption that farmers need support to access seed of improved varieties, 'beneficiaries' as well as agrodealers reported more negative than positive effects, particularly in view of developing sustainable business options to serve all farmers.

Seed system actors in both Kenya and Mali gave high priority to establishing managed stakeholder forums to improve cooperation and tap opportunities for reducing transaction costs and risks. Other priority actions identified by workshop participants in both countries targeted capacity building for farmers and seed sellers. Options given high priority in Kenya included breeding varieties with special attributes, reducing the length of seed delivery chains, improving information sharing among actors and better public access to comparative varietal-performance information. Strengthening participatory plant breeding was specifically rated as a priority in Mali.

Summary

Conclusions and entry points for sustainable seed system development

The need for **stronger actor orientation** to enhance seed system functioning at all levels is a major conclusion of this study. Furthermore, focus on enhancing relationships among actors, e.g. by regular dialogue and functional feedback loops, is crucial to enable individual actors to contribute to collective goals and understand other actors' needs.

Sustainable seed system development requires that **farmers' needs and capacities are a primary focus** since (a) farmers engage and have insights in all seed system functions; and (b) value must accrue to farmers and those who use the crop produce before other actor groups can obtain benefit. Such a 'farmer focus' requires that farmers are recognized as key actors rather than just as 'beneficiaries', and that their voices are actually heard on a continual basis.

Major potential for seed system development lies in **improved collection and sharing of varietal information and performance data**. Strengthening actors' capacities to collect, share and assess information about varieties and their comparative performances will contribute to dynamic, responsive seed systems in which well-informed decisions can be made.

Decentralized seed production based on farmer seed-producer groups and cooperatives can serve as the basis for an emerging locally-based seed industry, where market opportunities are limited for highly specialized, large-scale seed companies, or where farmers' needs for varieties are diverse. Such farmer enterprises integrate elements of traditional farmer-managed seed systems, such as short distribution pathways and trust among actors, while also speeding up innovation by collaborating with breeding programs in variety testing and development.

Plant breeding, as the source of value creation, needs to be regarded as an integral component of functioning seed systems. The diverse and intense discussions about varietal issues in our interviews and workshops also show the need for joint consideration of what demands for innovations actually exist in order for seed systems to advance, and which practical opportunities exist to build adequate funding mechanisms for achieving these goals.

Lastly, **seed systems in both Kenya and Mali could benefit from more rigorous assessments of how interventions, new technologies, policies and formal organizations influence seed system innovation** and sustainable development. Benefit and cost analyses for specific actor groups to guide decisions, rather than reliance on conceptual or assumed benefits, would provide clearer 'realistic field-views'. By shifting funds and resources from regulation and relief towards creative efforts such as capacity building, breeding and innovative dissemination strategies involving diverse types of actors, costs could be reduced and value increased where it is most needed — in rural areas, in the hands of small-scale farmers and their market partners.

Practical opportunities for addressing these entry points for sustainable seed system development through targeted action and capacity building, broken down by country and crop, are presented in the Annex of this study.

RÉSUMÉ

Introduction et objectifs

La semence est un point de départ essentiel pour améliorer la valeur et la productivité dans l'agriculture, elle fait donc l'objet de nombreuses politiques et interventions agricoles en Afrique. Cependant, il existe un débat permanent sur les avantages de telles interventions dans le système semencier, en particulier pour les petits agriculteurs.

L'objectif général de cette étude était de proposer un agenda pour soutenir le développement durable des systèmes semenciers dans deux pays d'Afrique subsaharienne : le Kenya et le Mali. Ce programme doit être basé sur les expériences et les connaissances des acteurs du système semencier qui contribuent à diverses fonctions du système et sont actifs à différentes échelles. L'étude a été commandée pour contribuer au Programme d'appui à la recherche pour l'innovation agricole (PARI)², une composante de l'initiative spéciale du gouvernement allemand « Un monde sans faim » (SEWOH).

L'étude porte sur les cultures céréalières de base, dont le maïs et le sorgho au Kenya et le maïs ; le riz ; le sorgho et le mil au Mali. L'étude a pour objectifs spécifiques de :

- Collecter des informations sur le contexte actuel du fonctionnement du système semencier, comprenant les données économiques de base ; les cadres politiques et juridiques, dans chaque pays et pour chaque céréale de base concernée par l'étude.
- Identifier les contraintes et les opportunités pour améliorer la dynamique des systèmes semenciers basées sur les connaissances et des capacités de divers acteurs dans chaque pays.
- Proposer un agenda pour le renforcement ciblé des capacités et le renforcement du processus collaboratif d'innovations dans les systèmes semenciers pour chaque pays.

Approche et méthodologie

On entend par systèmes semenciers dans cette étude des systèmes d'activité humaine qui sont établis et entretenus par des acteurs, c'est-à-dire des personnes qui poursuivent des objectifs individuels et collectifs en rapport avec les semences. Le but collectif d'un système semencier est de fournir aux agriculteurs des semences de qualité supérieure d'un choix raisonnable d'espèces et de variétés en quantité suffisante, à un prix abordable et au bon moment. Les fonctions fondamentales du système semencier envisagées ici sont des cadres juridiques adaptés, le développement des variétés, la fourniture de semences et leur diffusion. La valeur pour la production agricole et pour l'utilisation, créée par l'emploi de semences de qualité, fait partie intégrante du système.

Les innovations dans des systèmes complexes, comme les systèmes semenciers, nécessitent des changements dans les capacités individuelles des acteurs et dans leurs relations entre eux pour faciliter l'assimilation et l'application d'un savoir provenant de différentes sources. L'établissement d'un dialogue entre acteurs du système semencier et la définition de priorités basées sur des connaissances collectives peuvent donc constituer un point de départ pour l'innovation.

L'approche utilisée dans cette étude était de combiner un examen des données de sources secondaires avec une évaluation qualitative des perspectives des acteurs à l'aide d'entretiens semi-structurés, en face à face et en petits groupes. Les régions étudiées ont été choisies pour représenter les contrastes dans les niveaux d'adoption de variétés « améliorées » et les différentes conditions agro-écologiques en fonction des pays et des cultures.

² <http://research4agrinnovation.org>

Résumé

Les régions étudiées au Kenya étaient les « counties » de Trans Nzoia, Homabay et Tharaka Nithi. Au Mali, les régions ciblées furent celles de Sikasso, Ségou et Mopti, y compris la zone de riziculture irriguée de Niono.

L'étude a interrogé des acteurs de différentes catégories, dont des spécialistes en ressources génétiques, des sélectionneurs, des producteurs de semences, des vendeurs de semences, des agents de vulgarisation agricole, des agriculteurs, des commerçants de grains et des transformateurs, ainsi que d'autres acteurs soutenant la filière comme les services techniques étatiques et le personnel des ONG. L'étude a inclus des acteurs opérant à petite comme à grande échelle, et hommes et femmes (en particulier pour les agriculteurs, les commerçants de grains et les transformateurs).

Au Kenya, un total de 119 entretiens ont été menés du 7 au 24 février 2017, avec 222 participants. Au Mali, 163 entretiens ont été menés du 1^{er} au 21 mars 2017, avec 233 participants. En outre, des ateliers ont été organisés pour réunir un large éventail d'acteurs concernés afin de débattre ensemble et d'établir les priorités entre possibilités de développement du système semencier proposées dans chaque pays.

Résultats et discussions

Les deux pays disposent d'un immense potentiel inexploité pour la production des céréales vivrières ciblées dans cette étude, mais ils ne sont toujours pas complètement autosuffisants. Les importations de céréales vivrières sont importantes, totalisant 1,6 million de tonnes au Kenya (blé, riz, maïs et sorgho) et 0,3 million de tonnes au Mali (riz et blé) en 2013. Les politiques et stratégies agricoles des deux pays visent une production agricole accrue et cherchent à renforcer leurs secteurs agricoles en mettant en œuvre des mesures visant à accroître l'utilisation de semences commerciales; ces mesures comprennent la distribution gratuite de semences aux agriculteurs.

Des entreprises semencières privées et nationales sont actives au Kenya et leur nombre a augmenté au cours des 20 dernières années. Cela est dû, en partie, à l'importance du maïs au Kenya et à la présence de grandes exploitations commerciales ainsi que de petits agriculteurs. Cependant, les entreprises semencières privées du Kenya, à une exception près, ne gèrent généralement pas leurs propres programmes de sélection, mais organisent la production de semences et la commercialisation de variétés développées par le biais de programmes publics de sélection ou introduites depuis d'autres pays et diffusées au Kenya. Le secteur des semences certifiées du Kenya est dominé par une grande société parapublique, la Kenya Seed Company (KSC), qui détient une part de marché comprise entre 70 et 80%. Les entreprises du secteur privé, y compris les entreprises locales, régionales et multinationales, se partagent le reste du marché. Pour le sorgho et le maïs, les semences certifiées représentent respectivement environ 30% et 60% de la superficie totale ensemencée, à quelques variations près selon la zone étudiée.

Le Mali, en revanche, ne dispose pas de sociétés de sélection privées, mais les partenariats entre les programmes de sélections publiques et les coopératives d'agriculteurs sont courants. Les coopératives des agriculteurs qui produisent les semences sont les principaux producteurs et vendeurs de semences commerciales au Mali, la plupart des membres des coopératives étant eux-mêmes des petits agriculteurs. D'autres entreprises semencières commerciales achètent des semences certifiées auprès de ces mêmes coopératives de production semencière pour les commercialiser dans les zones périurbaines, ou auprès d'ONG et d'autres projets pour une distribution ultérieure. Les semences certifiées sont actuellement utilisées pour environ 5% de la superficie totale ensemencée de sorgho et de millet perlé, et entre 10% et 15% pour les cultures de maïs et de riz irriguées. Cependant, la part est plus élevée dans certaines zones de production à « fort potentiel » et plus faible dans les zones plus arides du nord du Mali. L'intérêt des agriculteurs pour les nouvelles variétés est élevé et le marché des semences commerciales se développe dynamiquement, en particulier pour le sorgho et le millet perlé.

Les résultats des entretiens avec les acteurs du système semencier sont présentés dans l'étude en relation avec les fonctions du système semencier et examinés pour constater les contributions aux trois dimensions de la sécurité du système semencier qu'impliquent la qualité, la disponibilité et l'accès aux semences. Les problèmes liés à la **qualité des semences** engendrent des besoins d'adaptation différents aux conditions de production et de

stockage et la valeur dans le cadre d'utilisations spécifiques. Les agriculteurs ont indiqué que plusieurs caractéristiques autres que, ou en combinaison avec, le rendement conditionnaient leur choix pour une variété. Un exemple est celui de l'adaptation aux conditions de production locales et aux caractéristiques de qualité relatives au traitement après récolte ou à des utilisations spécifiques. La qualité des grains et l'adaptation à la faible fertilité des sols représentaient les principaux sujets de préoccupation pour les petits agriculteurs, les hommes et en particulier les femmes. Par conséquent, une plus grande attention aux préférences différenciées des utilisateurs et liées au genre semble offrir un grand potentiel pour l'innovation du système semencier.

La diversité est un autre problème important lié à la qualité ainsi qu'à la disponibilité des semences. Ainsi, pour que les systèmes semenciers modernes soutiennent l'utilisation stratégique de la diversité variétale par les agriculteurs, ils doivent fournir des variétés adaptées aux conditions de production et aux objectifs des agriculteurs dans un contexte particulier, tout en répondant aux nouveaux défis et opportunités. Les cadres juridiques qui tendent à restreindre le type de variétés autorisées à entrer sur le marché et à retarder l'arrivée de nouvelles variétés dans les champs des agriculteurs ne sont pas particulièrement favorables à cet égard. Des options devraient être explorées pour utiliser ou étendre l'espace légal afin de faire en sorte que le système semencier augmente, plutôt qu'il ne limite, la diversité des options variétales à la disposition des agriculteurs.

Au Kenya, de nombreux agriculteurs ont connu une faible germination des semences commerciales malgré des exigences de qualité strictes et des mécanismes de contrôle. Les problèmes de qualité des semences ont été moins souvent mentionnés au Mali. Garantir la qualité des semences commerciales est donc une question exigeant une attention particulière, car elle augmente les risques de production et sape la confiance entre les acteurs, laquelle est cruciale pour un fonctionnement efficace du système semencier.

La **disponibilité des semences** est le résultat de nombreuses fonctions différentes qui contribuent à ce que les semences des variétés désirées soient disponibles en quantités suffisantes à une distance raisonnable et en temps opportun. La disponibilité des semences n'était pas *en soi* un véritable problème, car les quantités de semences étaient généralement suffisantes pour toutes les cultures étudiées au Kenya et au Mali. Cependant, on relève certains cas où la variété ou l'hybride préférée n'était pas disponible, ce qui a incité les agriculteurs à choisir une variété moins appréciée. Les facteurs contributifs mentionnés comprenaient l'insuffisance des semences de base, les retards dus au processus de certification, le manque de coordination entre les acteurs et les sociétés semencières ou les semenciers qui, en raison d'intérêts commerciaux, choisissaient de vendre d'abord des variétés qui correspondaient moins aux préférences.

La lenteur du renouvellement des variétés offertes aux agriculteurs des deux pays laisse supposer qu'il est difficile d'obtenir de nouvelles variétés améliorées sur le marché. Les sélectionneurs publics des deux pays ont souligné les contraintes causées par les fonds limités et la dépendance vis-à-vis des subventions de projets à court terme. Les retards causés par le processus d'homologation des variétés ont également été signalés. Plusieurs modèles de collaboration entre les partenaires des secteurs public et privé, ainsi que, dans certains cas, des tiers, sont présentés et envisagés en tant qu'options pour surmonter certaines de ces contraintes. Ces modèles vont des programmes de sélection publics en partenariat avec des entreprises semencières gérées par les agriculteurs à la collaboration temporaire d'organisations de sélection privées et publiques, et incluent également différents types de parties intéressées collectant des fonds pour la recherche publique sur la sélection pour répondre à leurs attentes.

Un examen plus approfondi des possibilités pour renforcer les coopératives d'agriculteurs dans leur collaboration avec d'autres acteurs du système semencier pourrait identifier des options rentables pour augmenter la disponibilité des variétés améliorées, en particulier pour des groupes d'utilisateurs spécifiques, pour certaines cultures cibles ou des agroécologies trop petites sur le marché pour susciter l'intérêt des entreprises de sélection privées. En outre, des alternatives dont le but serait d'inclure de nouveaux types d'acteurs (tels que les négociants en céréales) dans la dissémination des semences pourraient être explorées dans les zones où un réseau de points de vente de semences n'est pas complètement développé.

Résumé

La capacité des agriculteurs à **accéder aux semences**, y compris dans les cas où elles existaient matériellement, est également apparue comme un problème. Même si les semences semblent être relativement peu coûteuses au Kenya et au Mali, disposer des liquidités nécessaires pour acheter des semences peut être problématique pour certains groupes d'utilisateurs. Ces problèmes d'accès aux semences doivent être discutés dans le contexte où les semences dans les systèmes traditionnels gérés par les agriculteurs ont une faible valeur monétaire, mais une «valeur sociale» élevée, pour aboutir à une situation où les semences seraient toujours accessibles, même dans des situations difficiles. Des options ont été présentées et débattues pour permettre de surmonter les contraintes de liquidité et de trésorerie qui contribuent à limiter l'accès aux semences. Une attention particulière a été accordée aux différentes formes de financement par les chaînes de valeur qui ont été rencontrées au cours de l'étude.

La distribution gratuite de semences est un problème d'importance continue au Kenya, mais aussi récemment au Mali. Bien qu'elle soit apparemment justifiée par l'hypothèse selon laquelle les agriculteurs ont besoin de soutien pour accéder aux semences de variétés améliorées, les «bénéficiaires» et les négociants en semences ont signalé des effets plus négatifs que positifs, en particulier dans l'optique du développement de solutions commerciales durables pour tous les agriculteurs.

Les acteurs du système semencier au Kenya et au Mali ont donné haute priorité à la création de forums gérés par les parties prenantes pour améliorer la coopération et exploiter les opportunités de réduction des coûts et des risques de transaction. D'autres actions prioritaires identifiées par les participants lors de réunions tenues dans les deux pays ont ciblé le renforcement des capacités des agriculteurs et des négociants en semences. Les options hautement prioritaires au Kenya comprenaient la sélection de variétés dotées de propriétés particulières, la réduction de la longueur des chaînes de distribution des semences, un meilleur partage des informations entre les acteurs et une plus grande facilité d'accès aux informations comparatives concernant les variétés. Le renforcement de la sélection des plantes participative a été placé, de manière spécifique, au rang de priorité au Mali.

Conclusions

Une conclusion majeure de cette étude est la nécessité de **centrer la orientation sur les acteurs** afin d'améliorer le fonctionnement des systèmes semenciers à tous les niveaux. En outre, l'accent mis sur l'amélioration des relations entre les acteurs, par exemple par un dialogue régulier et une rétroaction efficace, sont essentielles pour permettre aux acteurs individuels de contribuer aux objectifs collectifs et de comprendre les besoins des autres acteurs.

Le développement durable des systèmes semenciers nécessite de se **concentrer sur les besoins et les capacités des agriculteurs** puisque a) les agriculteurs sont impliqués et ont des connaissances dans toutes les fonctions du système semencier ; et b) la valeur produite doit revenir aux agriculteurs et ceux qui utilisent les récoltes avant que d'autres groupes d'acteurs en tirent un bénéfice. Une telle « approche centrée sur les agriculteurs » nécessite que ces derniers soient reconnus comme les acteurs principaux plutôt que comme des « bénéficiaires », et que leurs voix soient effectivement entendues sur une base permanente.

Un important potentiel de développement du système semencier réside dans **l'amélioration de la collecte et du partage des informations sur les variétés** et des données sur leur performance. Le renforcement des capacités des acteurs à collecter, partager et évaluer les informations sur les variétés et leurs rendements comparatifs contribuera à fonder des systèmes semenciers dynamiques et réactifs qui peuvent faire l'objet de décision éclairées.

La **production décentralisée des semences à partir de groupes d'agriculteurs et de coopératives** peut servir de noyau pour un secteur émergent de production de semences au niveau local, dans lequel les opportunités du marché sont limitées aux très grandes entreprises semencières hautement spécialisées, ou lorsque les agriculteurs ont besoin de nombreuses variétés différentes. Les entreprises de ces agriculteurs intègrent des éléments des systèmes semenciers traditionnels gérés par des agriculteurs, comme des voies de distribution courtes et la

confiance entre les acteurs, tout en accélérant l'innovation en collaborant avec des programmes de tests et de développement de variétés.

La sélection végétale, en tant que source de création de valeur, doit être considérée comme une partie intégrante du fonctionnement des systèmes semenciers. Les discussions diverses et intenses sur les questions de variétés lors de nos entretiens et de nos ateliers illustrent également la nécessité d'une prise en compte commune des demandes d'innovations existant pour faire progresser les systèmes semenciers, et aussi pour établir des mécanismes de financement adéquats pour atteindre ces buts.

Enfin, **les systèmes semenciers au Kenya et au Mali pourraient bénéficier d'évaluations plus rigoureuses de la façon dont les interventions, les nouvelles technologies, les politiques et les organisations formelles influencent l'innovation** dans le système semencier et son développement durable. Baser les décisions sur l'analyse coût-bénéfices pour des groupes d'acteurs spécifiques plutôt qu'en fonction de bénéfices théoriques ou supposés permettrait de fournir plus clairement des « visions de terrain réalistes ». En transférant les fonds et les ressources de la réglementation et de l'assistance vers des efforts créatifs comme le renforcement des capacités et les stratégies de sélection et de diffusion novatrices impliquant divers types d'acteurs, les coûts pourraient être réduits et la valeur augmentée là où le besoin est le plus urgent : dans les zones rurales, entre les mains des petits agriculteurs et de leurs partenaires de marché.

Des opportunités pratiques pour aborder ces points de départ pour le développement durable du système semencier au moyen d'actions ciblées et d'un renforcement des capacités, ventilées par pays et par culture, sont présentées dans l'annexe de cette étude.

1 INTRODUCTION AND BACKGROUND

This study was commissioned in the framework of the Program of Accompanying Research for Agricultural Innovation³ (PARI), which brings together partners from Africa, India and Germany to contribute to sustainable agricultural growth and food and nutrition security in Africa. PARI forms part of the ‘One World, No Hunger’ Initiative (SEWOH) by the German government (BMZ, 2015) and receives funding from the German Federal Ministry for Economic Cooperation and Development (BMZ).

Seed is a pivotal entry point for enhancing value and productivity in agriculture, and is therefore the focus of agricultural policies and interventions in many African countries. Unlike other external inputs, seed cannot be used on an optional basis or replaced by other means or actions. This fundamental role of seed in crop production explains farmers’ interest in new varieties and the high importance of functional seed systems for food and nutritional security.

Historically, seed systems were largely managed by farmers and were tightly interconnected with cultural norms, social networks and collective goals for functions like genetic resources conservation, variety development, seed production, quality control, and dissemination (Badstue (2007); Badstue *et al.* (2003); Christinck (2002); Siart (2008); Delêtre *et al.* (2011); Dohr *et al.* (2015); Mucioki *et al.* (2016a). These farmer-managed seed systems are rapidly changing worldwide.

As specialized plant breeders develop varieties that are disseminated through new and different channels involving a variety of actors, forms of remuneration and needs for feedback and control may change or replace traditional institutions and practices. These processes have advanced differently in various countries and crops and their respective value chains (van Mele *et al.*, 2011).

Characterizing and understanding the current situation and dynamics of seed systems for staple cereal crops in different countries is essential to develop innovations for enhancing these important, complex, and often contrasting systems in an effective and sustainable manner.

A vital question addressed in this study is, therefore, what seed system interventions and developments could contribute to sustainable benefits for the full range of farmers, including those currently relying principally on farmer-managed systems, by addressing key opportunities and needs for crops vital for food security and income for all system actors. Given the diverse production conditions and goals of farmers and their market partners within and across the 47 countries of Sub-Saharan Africa, any proposed interventions would need to take this diversity and complexity into account.

2 STUDY OBJECTIVES

This study, considering the complexities mentioned above, seeks to identify development pathways, promising models and options that can be used to establish an agenda for dynamic and sustainable seed system development. It focuses on staple cereal crops (maize, rice, sorghum, pearl millet) in two contrasting countries, Mali and Kenya, and its realization involved a wide range of national actors, building on their capacities, priorities and opportunities. Discussions draw out insights from these experts regarding institutional options and specific business development opportunities in the seed sector.

Specific objectives are:

- To compile information about the current context of seed system functioning, including basic economic information, policies and legal frameworks, for each country and staple cereal crop considered.

³ <http://research4agrinnovation.org>

- To identify constraints and opportunities for enhancing seed system dynamics based on the insights and capacities of diverse actors in each country.
- To propose an agenda for targeted capacity building and strengthening of the collaborative process of seed system innovation for each country.

The approach described below could pave the way for future seed system development activities that could be pursued more widely across African countries.

3 APPROACH AND METHODOLOGY

In this chapter, we present basic concepts and issues on which the research approach is based, including information on seed systems and seed system functions, actor orientation and innovation processes, as well as the methodologies that were used in the study.

3.1 BASIC CONCEPTS AND ISSUES

The approach taken relies on our understanding of seed systems as human activity systems that fulfill specific functions, including seed system security, and that an actor-oriented approach is useful to assess problems and identify options for strengthening these systems. This study also takes into consideration some aspects of innovation processes and innovation systems. These basic concepts and issues will be briefly presented in the following sections.

3.1.1 SEED SYSTEMS IN GENERAL

A sustainable seed system will ensure that high quality seeds of a wide range of varieties and crops are produced and fully available to farmers and other related actors in a timely and affordable manner (FAO, 2017). Hence, a seed system functions well when farmers can access seed that corresponds to their preferences and needs, has the required quality, and is available in sufficient quantity at the right time.

Farmers are usually involved in multiple systems for producing or obtaining seed to meet their needs. These different seed systems are often broadly divided into ‘formal’ seed systems on the one hand, and ‘informal’, ‘traditional’, ‘farmer-managed’ or ‘local’ seed systems, on the other.

The formal seed system relies on formal actors (e.g. plant breeding and seed companies) that follow officially established procedures for variety development, testing, registration and marketing of seed based on laws established by governments. Formal seed systems typically follow a supply chain model, with breeding research and variety development at the beginning and farmers as customers at the end.

“Seed is one of the most crucial elements in the livelihoods of agricultural communities. It is the repository of the genetic potential of crop species and their varieties resulting from the continuous improvement and selection over time.”

FAO (2017)

In contrast, local or farmer-managed seed systems rely on the crop and seed production activities of farmers and are usually organized as a network involving other farmers and local markets or dealers. A recent study shows that in spite of large investments in formal seed systems, farmers accessed 90% of the seed they used through ‘informal’ channels in the six countries studied (including five in Sub-Saharan Africa) (McGuire and Sperling, 2016). These estimates are similar to those of earlier studies in which informal seed sources were estimated to account for 80-90% of all seed supplies in global agriculture (Almekinders *et al.*, 1994; FAO, 2004), although with considerable variation between countries and crops (Almekinders, 2000).

The division of seed system actors and components into formal and informal classes appears increasingly problematic since there is a growing degree of overlap between both systems. For example, varieties originally developed by the formal sector may enter the informal, and *vice versa*. Often, farmers increasingly engage in formal seed production and marketing, and local traders may offer local seed alongside seed from the formal sector. Moreover, civil society organizations have emphasized that farmer-managed seed systems are not informal in

The term ‘informal sector’, coined by the British Anthropologist Keith Hart in the 1970s, is usually understood as a system of economic exchange outside state-controlled transactions, where income is not recorded for taxation purposes and unavailable for inclusion in gross domestic product (GDP) calculations. It may include both legitimate (e.g. small-scale distribution of goods and services) and illegitimate activities (e.g. selling of stolen or smuggled goods, ‘black market’, etc.). This is why the term ‘informal sector’ has for some a clearly negative connotation (Hart, 1973; 1985). In contrast, farmer-managed seed systems were the only sources of seed for farmers over millennia and continue to be vital for many crops and varieties not offered by the formal sector; the production and dissemination of seed by farmers was accepted as part of their normal (and legal) agricultural activities over centuries. Hence, traditional or farmer-managed seed systems fulfill in many cases the legal criteria for customary law, the status of which may however be weakened if countries establish new formal laws that do not explicitly clarify the status of farmers’ customary practices in relation to the new law (Christinck & Tvedt, 2015). In many developing countries, farmers’ seed-related activities are tolerated where they do not interfere with rights of others established under formal law, e.g. plant breeders’ rights. Given this complex situation, the Brazilian environmental law expert Santilli (2006) has drawn attention to the fact that parallel legal systems co-exist for practices relating to seed and genetic resources in pluralistic and multi-ethnic societies. It would be the responsibility of states to accommodate these within a national legal system.

the way this term is commonly understood (see box). This is why we use an approach in this study that focuses on actors fulfilling specific roles in seed systems, without dividing them into formal and informal actor categories. This approach is explained in more detail below.

Distinct seed systems rely on different practices and rules. In farmer-managed systems, information and seed flow along social relationships, e.g. among neighbors, friends, relatives or local market partners. The compensation for giving seed depends on the social relationship between seed provider and recipient, ranging from no compensation to return of grain price or slightly more. The timing and modes of payment, if required, are flexible and include cash as well as in-kind compensations, e.g. grain for seed, seed for seed or labor for seed (Badstue *et al.*, 2003). In contrast, the price for seed purchased by farmers from agrodealers is commonly 2-5 times higher than the grain price (in some cases even 10-30 times higher) – and needs to be paid in cash (Christinck and Tvedt, 2015:25).

Quality issues are usually ‘ensured’ in farmer-managed seed systems based on visual inspection of the seed offered, reputation and trust among the partners involved in the transaction (Badstue *et al.*, 2003; Jones, 2014; Dohr *et al.*, 2015). Besides price and quality considerations, further reasons why a majority of farmers worldwide rely on farmer-managed seed systems include geographical proximity and familiarity with varietal characteristics, associated with lower risk. Therefore, farmer-managed seed systems are especially important in more stress prone environment and for farmers (including women and men) with limited cash flow or geographical mobility.

3.1.2 SEED SYSTEM SECURITY

Seed system security, i.e. the degree to which seed systems can actually fulfill their basic function of providing (all) farmers with sufficient seed of required quality at the time needed (see 3.1.1), is often assessed based on three aspects commonly used in food security frameworks, namely (1) availability, (2) access and (3) quality (Sperling, 2008; Sperling *et al.*, 2008).

Here, ensuring *availability* of seed means that seed has to be physically available in specific locations, where it is needed, and at the right time. *Access* entails the individual person's possibilities to get seed, which can differ for different groups of people, depending for example on cash requirements, social relationships or other issues that may entitle an individual to get seed — or not. Lastly, *quality* includes the varietal traits (e.g. relating to environmental adaptation and use characteristics) as well as the technical seed quality (e.g. germination capacity, purity etc.).

The original focus of Seed System Security Assessments (SSSAs) was on better targeting seed aid interventions (Remington *et al.*, 2002; Sperling and Cooper, 2003; Sperling, 2008). The basic idea 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 framework has attracted interest from other researchers because it can also help identify strategic entry points for other interventions, not only in disaster situations. An assessment that takes availability of, access to and quality of seed into account could help clarify how existing seed systems can be strengthened and developed further, and based on which considerations new institutions and regulatory frameworks can be built up in situations where traditional seed systems have become weak (Christinck *et al.*, 2014). The concept of seed system security is also closely related to issues such as resilience and sustainability in the context of seed system development.

In this study, we use the three above mentioned aspects of seed system security (availability, access and quality) in Chapter 6 to discuss how ongoing or proposed interventions relate to seed system security, based on the findings presented in Chapters 4 and 5.

3.1.3 SEED SYSTEMS AS HUMAN ACTIVITY SYSTEMS

Our attempt to avoid the limitations of dividing seed systems into formal and informal categories leads us to conceptualize them as human activity systems (Checkland, 1981:115). A human activity system, which is established and maintained by human actors, can be

A human activity system "is an assembly of people and other resources organized into a whole in order to accomplish a purpose. The people in the system are affected by being in the system, and by their participation in the system, they affect the system. People in the system select and carry out activities – individually and collectively – that will enable them to attain a collectively identified purpose."

Banathy, 1997

defined at three levels: (1) the collective purpose it serves; (2) the individual purposes of its members; and (3) the relations with and contributions to the larger environment, in which it is embedded (Banathy, 1997).

The collective purpose of a seed system can be described as the ability of the system to provide farmers with seed of the varieties they and their market partners require in sufficient quality and quantity, at the time needed, and at an affordable price.

A human activity system “is open to and interacts with the environment; depends on it and contributes to it. The nature of its relationship with the environment is mutual interdependence. This interdependence imposes constraints and expectations on both the system and its environment responsively. The environment is expected to provide the resources and support that are required by the system.”

Banathy, 1997

A human activity system “maintains sets of relations – sustained through time – among those who are in the system. The maintenance of these relations is of primary importance. The process by which these relationships are maintained is the system’s regulation – the rules of the game – and the limits within which these rules can be sustained are the conditions of the system’s stability through time. It is here where commitment (to shared purpose) and motivation (to carry out activities) play such an important role.”

Banathy, 1997

The individual purposes of seed system actors can be diverse. The goal of one actor could be to ensure family food security by growing a variety with stable and high ‘food yield’, while another could seek to optimize income to fulfill personal or family responsibilities, whereas others may pursue both of these or other goals simultaneously.

The ‘larger environment’ of level three entails the agroecological conditions as well as the socio-cultural ‘setting’, including current social norms, which influence the goals and activities of actors, and their interactions. This larger environment of seed systems can vary over space and time. For example, system actors may face different agroecological and sociocultural conditions, or have differing potential to contribute to or benefit from seed system development. Cultural norms relating to seed systems can evolve over time as new options and actors emerge, and as agroecological conditions, including climate, soil or land use, change. Seed system stability and resilience requires some level of adaptive capacity, including the capacity to innovate. In this regard, the system relies primarily on the capacities of the actors and their collective ability to adapt to current and anticipated changes (see Sections 3.1.5, 3.1.6).

Thus, recognizing and enhancing relationships among actors is important both for sustainable seed system development as well as for understanding collective and individual goals and interactions with the larger environment. Interventions that strengthen or challenge these relationships (e.g. benefits accruing for all actors or only for some at others expense) or system components (e.g. biodiversity) may either enhance or threaten the system’s stability in the longer term. Furthermore, the actions individuals take to pursue their goals can cause tension in the seed system if they affect other actors’ activities, the collective goal or the larger environment. One example could be the emphasis on a particular variety or variety type particularly desired by grain processors but neglecting diversity of other variety types that smallholder farmers may want to optimize to achieve food security and resilience. Furthermore, seed companies may prefer to promote a limited number of varieties to reduce transaction costs, while farmers may be interested in choosing from a wide array of options. Hence, seed system actors, in pursuing their individual goals, can have shared as well as diverging interests, depending on their roles (Christinck *et al.*, 2014).

Thus taking the perspective of seed systems as human activity systems helps overcome the common divide between so-called formal and ‘other’ seed systems by seeing them as one system in which diverse actors pursue their goals and respective activities. Furthermore, the focus here goes beyond assessing the flow of seed, money and information by emphasizing the role of actors for maintaining and enhancing seed systems, including relations among them, which should be based on mutual trust, shared motivation and commitment, for ensuring seed system functioning, dynamics and resilience.

3.1.4 SEED SYSTEM FUNCTIONS

We suggest focusing on five basic seed system requirements or functions that are necessary for a seed system to be effective. These basic functions are (1) provision of a legal framework; (2) variety development; (3) seed supply; (4) seed dissemination; and (5) crop production and use. Based on a human activity system perspective, these functions are seen to be embedded in specific socio-cultural and agroecological contexts (Figure 1).

The legal framework clarifies the relations among actors, and is – at best – intended to be supportive to the actors' collective capacity to innovate and adapt the system to meet current and future needs. By granting access and clarifying the relationships among actors and their respective rights, the legal framework is of fundamental importance for the distribution of costs, benefits and risks in a seed system, and has a large impact on the type of actors present and the products that can emerge from it. By defining what 'legal' or 'illegal' actors, activities and products are, its influence goes beyond establishing quality standards, even though this might be the stated objective. Therefore, the legal framework is not considered here as part of a general sociocultural 'environment', but as integral part of the seed system.

Variety development 'nurtures' the seed system by providing the basis for value creation at other levels. Seed supply and dissemination are of paramount importance to ensure that this potential can be fully tapped, e.g. by

The seed system function 'crop production and use' is close to what is called 'value for cultivation and use' (VCU) in official variety release procedures. However, commonly used VCU criteria for cereal crops, like grain yield, resistance to diseases and in some cases criteria of relevance for industrial processing, apparently do not fully correspond to the multiple types of value that these crops may have for farmers in developing countries.

ensuring biological and technological seed quality, and effective distribution to farmers, so that breeding progress reaches farmers' fields and supports value creation 'from farm to plate' and beyond, e.g. regarding individuals' nutritional and health status.

This is why crop production and use are conceptualized here as integral functions of seed systems, since the people involved in these activities, e.g. farmers, farm households and their market partners, are the ones who shape the demand for seed of specific varieties, for specific traits, or for seed of a required quality, by their

purchase decisions. A more common way of framing this would be that seed systems should be 'fully integrated into crop value chains'. However, without considering the full range of actors, all of their diverse goals, forms by which they cooperate, as well as the types of value created as integral part of seed system functions, the characterization will remain incomplete. Value creation can be diverse in African farming and food systems, ranging from manual on-farm processing and auto-consumption to networking and non-monetary exchange to large-scale industrial processing of products such as flour and beer. 'Crop production and use' is meant to cover the full range of these activities, even if they may not fully correspond to the common understanding of 'value chains'.

For a seed system to be functional, it is further required that relevant information is shared among the actors, that value is created at all levels, and that it is compensated for to ensure ongoing and future activities, e.g. by cash flow among the actors, or by outside funding, e.g. of public breeding programs. Thus, value creation, financing and communication are essential to ensure seed system functioning, and will be investigated further in the course of this study.

We are aware that our proposition of seed system functions is different from what others may understand as core functions of seed systems. The reason is that a narrow focus, e.g. on seed production, quality control and delivery, bears a risk of overlooking aspects that are important for the actors' decision-making and thus the seed system's overall functioning (see Sections 3.1.5 and 3.1.6).

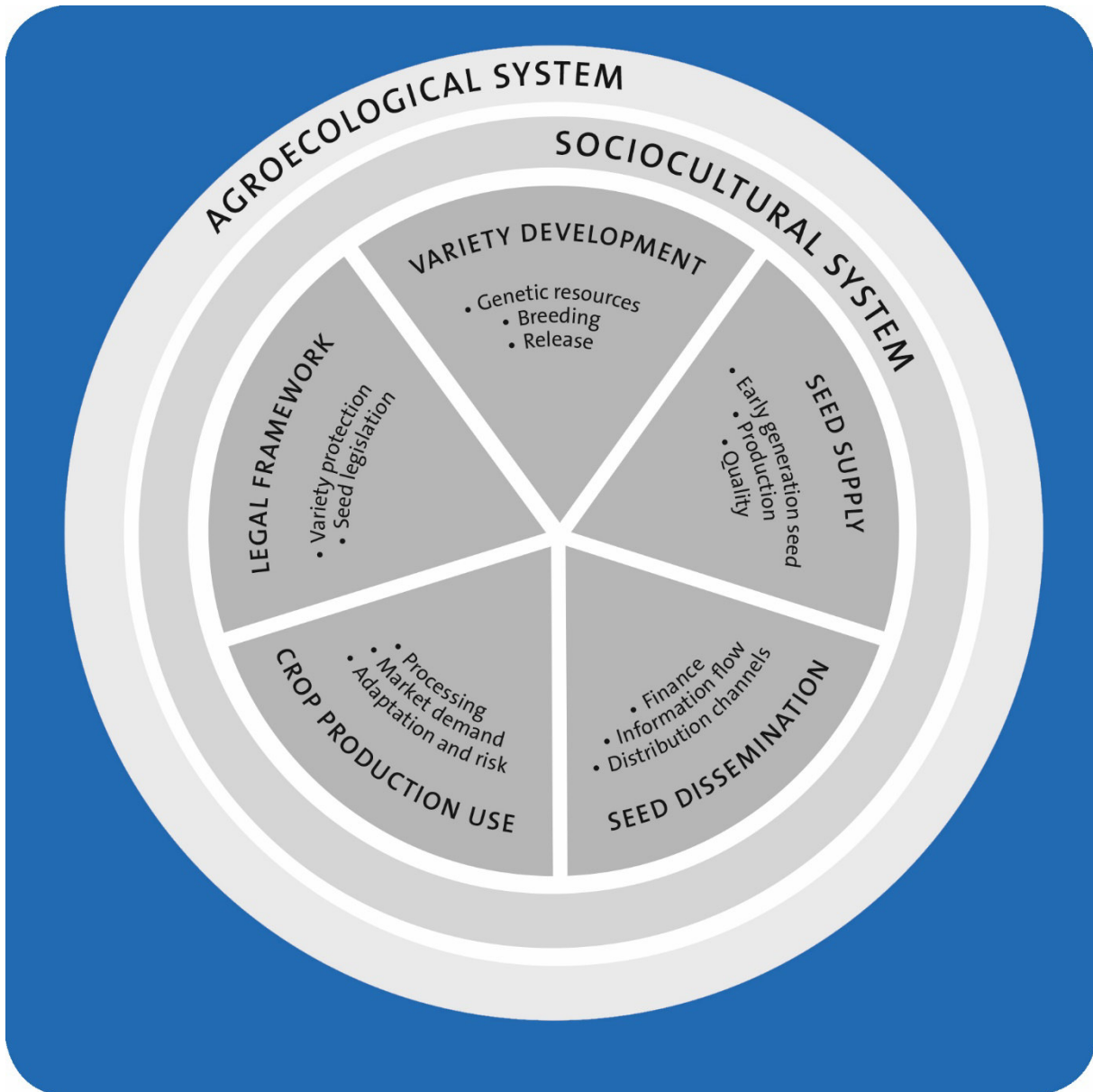


Figure 1: Basic seed system functions, embedded in larger socio-cultural and agroecological contexts, based on a human activity system perspective that a seed system is established and maintained by human actors to fulfill collective and individual purposes.

3.1.1.5 AN ACTOR-ORIENTED APPROACH TO ASSESSING SEED SYSTEMS

Recognizing seed systems as human activity systems makes it necessary to look closely at the actors and their goals, activities and relationships. The so-called actor-oriented approach focuses on understanding the individual actors' perspectives, needs and goals in relation to an identified problem, issue or project, or to change that is envisioned (Long, 2001).

Changes in human activity systems require actors to modify their actions, individually or collectively, which may also involve changes in relationships among the actors, or new types of actions requiring participation of new actors. For example, if seed certification procedures are newly introduced to a country, this goes hand in hand with the need to build up procedures for seed quality control, and the people involved in such activities will then become new actors in the seed system.

There are two basic ways of facilitating changes in human activity systems: (1) 'sticks and carrots', e.g. subsidies, prohibition or other incentives and disincentives imposed by powerful actors, e.g. governments or donors; or (2)

'self-driven change' that is based on new insights of actors, or new opportunities, e.g. through joint learning and collective action (Albrecht, 1994; Christinck and Kaufmann, 2018).

"The thinking, behaviour and choices of social actors, whether individual or collective, are shaped by many factors. Cultural disposition, the distribution of power and resources, past experience, life style, emotions and feelings [...], individual concerns, personal habits and peculiarities: all these have an influence in shaping choices. To escape narrow rational choice approaches, Long always has insisted to contextualise actors' 'behaviour'. All over his work he refers to notions such as cultural repertoires and social networks to show that, and how, social actors embed their actions, the strategies they devise and the choices they make in a social and cultural environment which is largely taken for granted but which, nevertheless, is shaped by actors themselves."

Hebinck et al., 2001

Self-driven change is usually more difficult to achieve, particularly where individual actors' activities are mutually interdependent or interests partly diverging, such that trade-offs exist and negotiations are required — like for example in seed systems (see Section 3.1.3). However, self-driven change of what the actors themselves want helps mobilize their own capacities and resources, builds on their intrinsic motivations and is usually more sustainable and lasting than changes brought about by incentives or disincentives imposed from outside.

Hence, understanding individual actors' perspectives and needs in relation to seed system development is assumed here to offer new entry points for targeted seed system interventions that support and facilitate self-driven change based on the actors' own insights. While these can obviously be assessed only based on inter-

views with those actors who are presently involved, problems and challenges identified by them, as well as expressed needs for adaptation and change, offer opportunities for new actors to develop solutions that are suited to other actors' needs, or to establish strategic partnerships.

A particular strength of the actor-oriented approach is seen in its ability to elucidate how external interventions, e.g. policy interventions, 'unfold' on the ground, when implemented in a social setting where local actors are already pursuing their own 'projects' to maintain, adapt or challenge existing structures or practices. Hence, such interventions tend not to be implemented in a linear manner, but are usually re-interpreted and renegotiated by local actors, who continue pursuing their respective goals (Masaki, 2007:24-26).

This may lead to discrepancies between 'official' discourses and local outcomes of interventions. Hence, an overarching goal of the actor-oriented approach is to assess *"how geographically distant actors, contexts and institutional frames shape social processes, strategies and actions in localized settings"* (Long, 2000:192). Critics of actor-oriented approaches mainly focus on the issue of how much power and 'room to maneuver' local actors actually have (which obviously differs among cases), and how overarching socio-cultural trends that are rather weakly linked to the human activity system in question (e.g. globalization or individualization) connect to local spheres (Masaki, 2007).

3.1.6 INNOVATION AS A COLLABORATIVE PROCESS

A common concept of innovation is “the process of translating an idea or invention into a good or service that creates value or for which customers will pay⁴” (see box). Hence, the users’ perspective on the value that is created by a new type of good or service is crucial for an innovation to be successful.

“To be called an innovation, an idea must be replicable at an economical cost and must satisfy a specific need. Innovation involves deliberate application of information, imagination and initiative in deriving greater or different values from resources, and includes all processes by which new ideas are generated and converted into useful products.”

Source: <http://www.businessdictionary.com/definition/innovation.html>

choices from a set of opportunities by (a) having freedom to choose, and (b) availability of options to choose from. The framework suggested by these authors can be used to explain why the classical approach to agricultural intensification is only successful as a strategy where both agroecological potential and human capabilities are sufficiently high. In other cases, different strategies such as agricultural or income diversification or coping strategies in general may be more appropriate.

Even people in the same village may differ in their capabilities depending on social difference that may affect their access to productive resources, information, services, or their freedom to make choices. Gender is one important example of social difference that influences individual capabilities and shapes preferences for specific varietal traits (Christinck *et al.*, 2017; see also Section 6.4.1).

A common concept of innovation in international agricultural research is one of developing technologies or practices and introducing them to a farming system from the outside, with farmers being the ‘adopters’ of these technologies in a more or less passive mode.

Replacing one plant variety by another is not as simple as an innovation as it appears at first instance; for example, many ‘high yielding’ varieties result in more grain yield, but less straw or other by-products that create value in other farming system components, e.g. dairy or meat production; furthermore, they may require additional inputs or different technologies for harvesting, processing and storage, or correspond differently to quality requirements of end users. Hence, new varieties may necessitate system adaptation at various levels.

In relation to seed, understanding the value that is associated with it is far from trivial; it can vary for different types of users, e.g. depending on agroecological conditions, available infrastructure, resources and assets, market access, as well as risk and vulnerability considerations (Bellon, 2006).

Gatzweiler and von Braun (2016) suggest distinct innovation strategies for different groups of smallholder farmers along a gradient of human capability and agroecological potential. Following a concept introduced by Sen (1999), human capability is the ability of people to make

choices from a set of opportunities by (a) having freedom to choose, and (b) availability of options to choose from. The framework suggested by these authors can be used to explain why the classical approach to agricultural intensification is only successful as a strategy where both agroecological potential and human capabilities are sufficiently high. In other cases, different strategies such as agricultural or income diversification or coping strategies in general may be more appropriate.

Even people in the same village may differ in their capabilities depending on social difference that may affect their access to productive resources, information, services, or their freedom to make choices. Gender is one important example of social difference that influences individual capabilities and shapes preferences for specific varietal traits (Christinck *et al.*, 2017; see also Section 6.4.1).

A common concept of innovation in international agricultural research is one of developing technologies or practices and introducing them to a farming system from the outside, with farmers being the ‘adopters’ of these technologies in a more or less passive mode. However, this model works for only relatively simple innovations, such as for example replacing one product with another, improved one that fulfills similar functions; otherwise, there is a risk of overlooking critical aspects of context, i.e. the implications a new technology may have on the system as a whole, or on certain components of it (see box). Examples of more complex innovations would include changes where several measures or actions need to be altered by various interdependent actors, or where the entire system needs to be adjusted to address new or broader objectives. In such cases, a successful

⁴ <http://www.businessdictionary.com/definition/innovation.html> (23 April 2017)

transformation of the system to a new level requires a learning process involving those actors who establish and maintain the system through their collective actions (Restrepo *et al.*, 2014; Moschitz *et al.*, 2015).

The knowledge spiral or SECI model, presented by Nonaka and Takeuchi (1995), provides a conceptual model for this type of collaborative innovation process, facilitating innovation that is based on the actors' own expertise while also integrating relevant outside knowledge. The SECI process includes four stages: (1) *socialization* (e.g. of previously disconnected actors); (2) *externalization* (e.g. of knowledge held by diverse actors); (3) *combination* (e.g. connecting the shared knowledge of diverse actors); and (4) *internalization* of the new connected knowledge (e.g. by embodying it in the form of new technologies, practices or forms of cooperation). Figure 2 shows the SECI process schematically and shows its correspondence to the three phases of a collaborative learning process (*dialogue*, *discovery* and *application*) identified by Restrepo *et al.* (2014) based on theoretical considerations and an assessment of case studies.

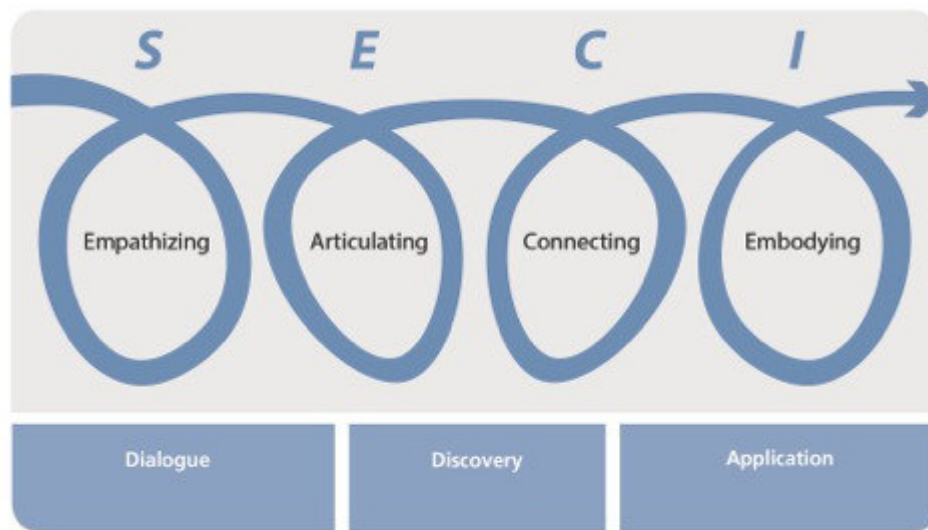


Figure 2: SECI model for innovation, including the four steps of *Socialization*, *Externalization*, *Combination* and *Internalization*, corresponding to the three phases (*dialogue*, *discovery* and *application*) of a collaborative learning process (Source: Restrepo *et al.* (2014), based on Nonaka and Takeuchi (1995)).

In our study, the first of the above-mentioned stages of a collaborative innovation process (dialogue phase) was initiated with seed system actors in Kenya and Mali, based on identification of actors, bringing them together, articulating and sharing knowledge and experience held by various actor groups (see Sections 3.2.6-3.2.9).

3.2 METHODOLOGY USED

The methodology used in this study was guided by the concepts introduced above. These perspectives were used to determine the nature of the desk review of written documents, the choice of the study team and partners, crops and countries (including areas within each country) to study, the choice of interview partners and workshop participants, and the structures and approaches used for conducting the interviews and workshops.

3.2.1 Desk Review of Written Documents

Written documents and published statistical data were reviewed to gather information on the general contexts of agricultural and seed sector development of both study countries. This information included quantitative data, e.g. basic economic information, crop yields, grain imports and exports, food and seed aid, as well as information on seed production and use. Furthermore, the legal frameworks and procedures for variety registration and release were described.

The results were compiled in preliminary reports, which were then used as source material for the final report and amended later on where necessary. In cases where data were not publicly available, we tried to get information directly from international and national organizations working in the respective country.

3.2.2 STUDY TEAM AND PARTNERS

The study was conducted between November 2016 and April 2017 and involved three weeks of fieldwork in Kenya and three and half weeks in Mali. The study was implemented in close collaboration with the National Agricultural Research Institutes (NARIs) of the selected countries, the Kenya Agricultural and Livestock Research Organization (KALRO) and the *Institut d'Économie Rurale* (IER) in Mali, both partner organizations of PARI.

The study team involved plant breeders, agricultural economists, freelancers and university students in rural development or communication and extension, and an agricultural social scientist. Further assistance was provided occasionally by field assistants for translation to local languages, and documentation of interviews. The local co-consultants were selected based on previous knowledge and recommendations; important criteria for selecting members for the study team were proven experience in gender-sensitive research, and in conducting qualitative interviews. Interviews were sometimes conducted simultaneously in different study sites with the help of the local co-consultants (see below). They also helped to organize and implement the multi-stakeholder workshops and/or contributed as co-authors of the report.

The Kenya fieldwork was supported by Dr Wellington Mulinge, Economist at KALRO, Dr Charles Wasonga, freelance plant breeding and seed expert, Homabay, Dr Simon Kimenju, Economist at Agri-Food Economics Africa, Nairobi; and Eric Murithi, BSc student in Rural Development at the University of Nairobi.

The fieldwork in Mali was supported by Alpha Kergna, Economist at IER; Samuel Guindo, development agent at Niono; Hamidou Guindo, MSc student at the Institut Polytechnique Rural, Katibougou; Gabriel Coulibaly, freelance expert in agricultural communication and extension, Bamako; and Joel Tangara, development agent in Kou-tiala.

3.2.3 CHOICE OF COUNTRIES

The study focuses on Kenya and Mali, countries situated in East and West Africa, respectively (Figure 3). These countries represent highly contrasting contexts for breeding and seed systems. Kenya was the first country in Africa to join the International Union for the Protection of New Varieties of Plants (UPOV) in 1999. Kenya has considerably longer experience with building institutions and procedures related to formal variety testing, registration and release than West African countries like Mali, which are presently in the process of adapting their respective institutions and procedures based on obligations deriving from their membership to the African Intellectual Property Organization (OAPI) and the Economic Community of West African States (ECOWAS).

Kenya has a long history in science-based plant breeding, with the first public maize breeding program being established in 1955 in Kitale, resulting in the first release of a variety in 1961 and the first hybrid variety in 1964. Since the establishment of the government-owned Kenya Seed Company (KSC) in 1956, a growing seed industry has developed in the country, focusing on a variety of crops. In 2005, 50 seed companies were registered in Kenya, dealing with cereals, oil crops, horticultural crops and Irish potatoes. In 2010, the number of registered seed companies in Kenya had grown to 82 (Sikinyi, 2010).

The national maize breeding program in Mali began operating about two decades later than in Kenya, with the first variety being released in 1972 and the first hybrid in 1984 (CIMMYT, 2015). Substantial engagement of researcher-led sorghum breeding occurred since the 1980s, and included collaboration with international organizations and initiatives such as the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), and Regional Sorghum Research Networks which first became operational in 1986 (ABSF, 2010).



Figure 3: Geographic location of selected study countries, Kenya and Mali.

Furthermore, the number of seed companies in Mali is much lower than in Kenya, and purchasing seeds is still uncommon in many areas for several or all staple cereals grown.

It was thus expected that these country contrasts could lead to differentiated priorities and needs for seed system interventions corresponding to the different contexts. More details regarding the general economic and political settings of both countries are presented in Sections 4.1 and 5.1 for Kenya and Mali, respectively).

3.2.4 CHOICE OF CROPS

Four cereal crops were selected for the purpose of this study: maize and sorghum in both countries, and pearl millet and rice in Mali. The study in Kenya focused on maize, which is the main staple crop, and sorghum as a more traditional cereal crop which is grown on less area and often in drier zones. Pearl millet and sorghum, in contrast, play important roles in Malian farming and food systems, being grown on areas larger than those for maize or rice, although all four cereals have similar production levels based on tonnage of grain. More details on the economic importance of these cereals are presented in Sections 4.1 and 5.1.

The four selected crops represent different production systems and agroecologies. In general, maize and rice require more water and higher levels of soil fertility compared to sorghum and pearl millet. Furthermore, the selected crops represent different types of reproduction biology, with rice and sorghum being predominantly self-pollinating crops and maize and pearl millet highly cross-pollinating. Whether a crop is self- or cross-pollinating has important consequences for the breeding methods that can be used and the possibilities for farmers to maintain distinct varieties on their farms.

Since seed systems need to serve multiple crops and agroecologies, it was hoped that examination of this range of cereal crops would provide a better overview of challenges and opportunities for seed system development than by focusing on single crop.

3.2.5 CHOICE OF STUDY AREAS

For each country, study areas were selected based on existing administrative units ('counties' in Kenya and 'cercles'⁵ in Mali). Among these, areas with higher and lower adoption levels of 'modern' varieties were identified for each of the cereal crops we focused on in this study, based on literature review and discussion with researchers from the cooperating national research institutes. Finally, whenever possible, those areas where several of the target crops were grown with either high or low expected adoption levels of modern varieties were selected as study areas. Since 'adoption' is a result of a variety of factors, the selected study areas vary for agroecological conditions that are described in more detail below.

STUDY AREAS IN KENYA

Kenya, a country lying on the equator, has highly variable agro-climatic conditions due to contrasting elevations, ranging from sea level to the peak of Mount Kenya at 5197 m above sea level (a.s.l.), and the corresponding variations in rainfall patterns and quantities. Furthermore, soil conditions vary due to differences in rainfall, topography and parental material. The predominant soils in Western Kenya are highly weathered tropical soils, while soils in highlands of central Kenya are younger soils of volcanic origin. The coastal soils of Southeastern Kenya tend to be coarsely textured and low in organic matter. Soil salinity is widespread and hinders irrigation in some areas. Most of the country (80%) is arid and semi-arid, where pastoral and agropastoral production systems prevail, whereas forest (3%) and cropland (17%) compose the remaining area (FAO, 2005). The locations of major cities and rainfall isohyets (Figure 4) and the relative expected levels of farmer adoption of 'modern' varieties (Table 1) are presented below for the areas selected for study.

Table 1: The study areas and their relative expected levels of 'modern' maize and sorghum variety adoption in Kenya.

	Maize	Sorghum
Higher adoption level	Trans Nzoia County Capital: Kitale	Homabay County Capital: Homabay
Lower adoption level	Homabay County Capital: Homabay	Tharaka Nithi County Capital: Kathwana Sub-County seat: Marimanti, major town in study area

Yield levels of maize and sorghum vary widely among the three selected study locations. Average maize yields for the period 2012-14 are reported to be 4.1 t/ha in Trans Nzoia County (high adoption of modern maize varieties) compared to 1.6 t/ha in Homabay County (low adoption). Average sorghum yields for the same period are reported to be 1.4 t/ha in Homabay County (high adoption of modern sorghum varieties) and 0.5 t/ha in Tharaka Nithi County (low adoption)⁶. Thus, in the counties selected for studying high adoption conditions, yield levels are above the national average yield of the selected crop and in those selected for studying low adoption conditions, they are below average (see also Section 4.1). The agroecological conditions in each of the selected study areas are described below in more detail.

⁵ The term 'district' is used in this study as a translation of 'cercle' for improved readability.

⁶ Calculated from information provided by MoALF (2016) for these counties.

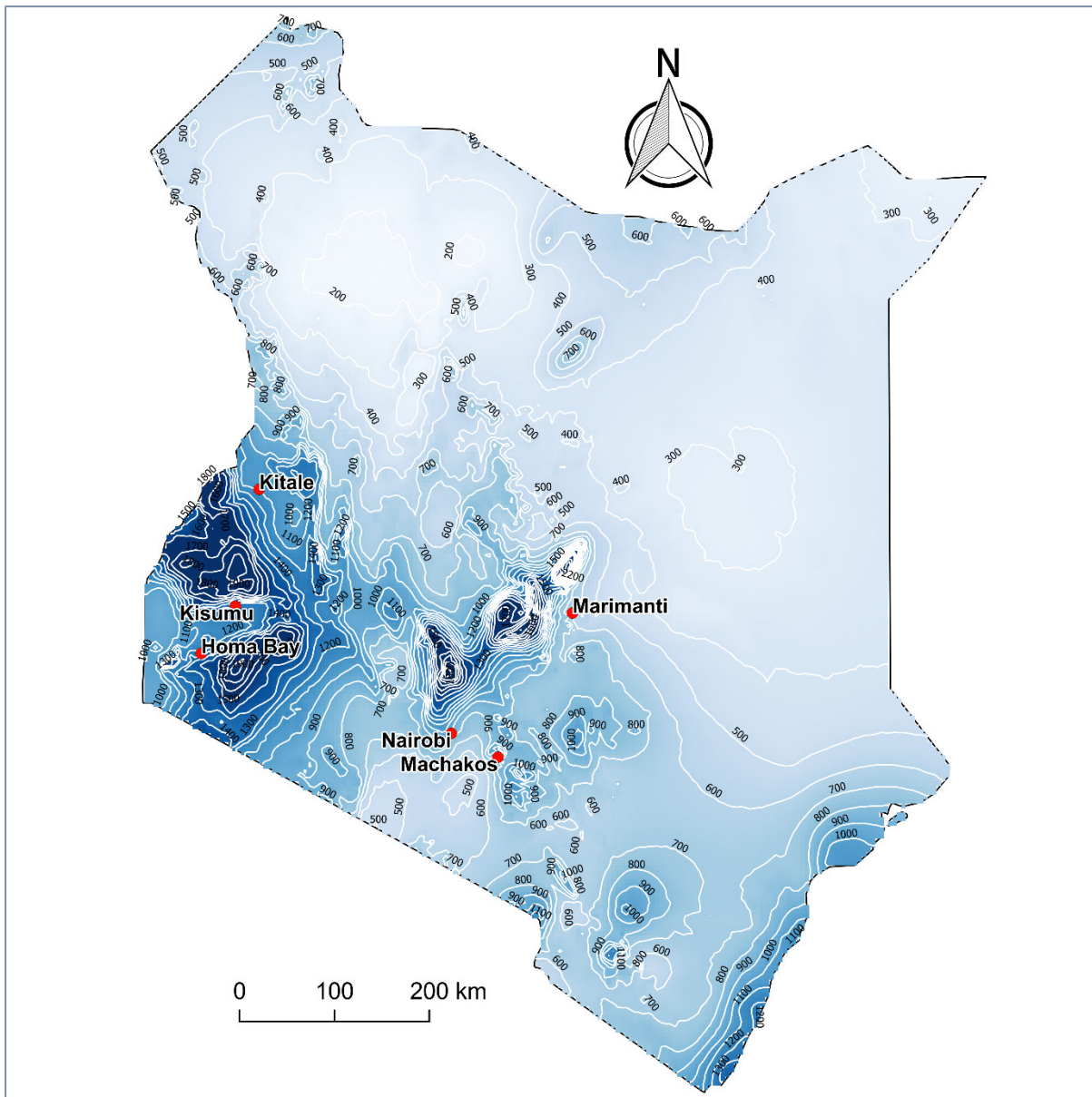


Figure 4: Study locations in Kenya with mean annual rainfall isohyets in mm; Marimanti is a town in Tharaka Nithi County; Kitale is the capital of Trans Nzoia County.

Trans Nzoia County, often called 'Kenya's bread basket', shares its western border with Uganda and has a highland equatorial type of climate. The average elevation is 1800 m a.s.l., ranging from 1400 m a.s.l. in the north to 4313 m a.s.l. at Mount Elgon. According to the elevation, mean annual temperatures range between 10 and 30° C, and mean annual rainfalls from 900-1400 mm, distributed in a bi-modal rainfall pattern, with main rains occurring from March/April to May/June, while the short rains fall from July/August to October/November. One third of the maize produced in Kenya is produced in Trans Nzoia, along with wheat, coffee, tea and a variety of horticultural crops. Small-scale farmers on average have 0.6 ha of land while the large-scale farmers hold an average of 12 ha (Trans Nzoia County Government, 2013).

Homabay County is situated in Southwestern Kenya at the southern shore of Lake Victoria. Like Trans Nzoia, it borders on Uganda to the west. The county can be broadly divided into a drier lowland area towards Lake Victoria and a wetter upland plateau inland. Altitudes range from approximately 1100-1200 m a.s.l. at the shores of Lake Victoria to around 1500 m a.s.l. at the upland plateau. This environmental diversity is reflected in the diversity

of crops grown, including coffee and tea, cotton, sugarcane, sisal, various oil crops, pulses and tuber crops, horticultural crops, such as pineapple and tomatoes, as well as maize, sorghum and finger millet. More-over, the county hosts a rich natural biodiversity, including forests and tropical islands. The mean size of landholdings in Homabay is 2.4 ha (Homabay County Government, 2013).

Tharaka Nithi County, located around 180 km north-east of Nairobi, covers the widest range of elevation, going from less than 600 m a.s.l. at Tharaka Town in the east of the county to nearly 5200 m in the western end of the county. The county can be roughly divided into an upland area, receiving high rainfall, and the semi-arid lowland areas. Soil erosion is severe in Tharaka Nithi. Mean annual rainfalls are as low as 500 mm in the eastern part of Tharaka Nithi, whereas they reach as much as 2200 mm in the higher elevation areas in the west. Rainfall is bimodal in the sorghum and maize production areas, with the long rains from March/April to Ma/June and the short rains from October to December, with rainfall distribution tending to be unreliable particularly at the lower elevations receiving less rainfall. The temperatures in the lowlands range from 26 to 36° C, sometimes even exceeding 40° C. Crops grown in Tharaka Nithi County include maize, pulses, and other food crops in the lowlands, as well as coffee and tea in the medium and higher altitudes. The mean size of landholdings in Tharaka Nithi is 4.8 ha, with small-scale farmer working on 2.9 ha (average), and large-scale farmers on 6.7 ha (average) (Tharaka Nithi County Government, 2013).

Interviews were also conducted at **Kisumu**, where there is an office of the Kenya Plant Health Inspectorate Service (KEPHIS) responsible for Homabay, and extension agents from Homabay were met. Additional interviews were held in **Machakos County**, including those with the KALRO Sorghum Breeding Program, the KALRO-Katumani Kenya Seed Unit, and a private seed company marketing maize and sorghum seed, and in **Nairobi**, where non-government organizations (NGOs), KALRO scientists, scientists working with the International Maize and Wheat Improvement Center (CIMMYT) and the Seed Trade Association of Kenya (STAK) were met.

STUDY AREAS IN MALI

Mali is a landlocked country in West Africa with predominantly flat plains interrupted by plateaus and the inland delta of the Niger River. The average elevation is 200 m a.s.l. The majority of Mali's land surface (65%) is covered by desert and semi-desert, which stretches from the Sahara Desert in the north down to the Sudanian-savannah zone in the south-east. The Niger River creates a fertile strip inside the country, forming an extended inland delta with lakes and flood between Mopti in the south to Timbuktu in the north. Mean annual rainfalls range from 1000-1200 mm south of Bamako to less than 100 mm in the northern desert areas, with high temporal and spatial variability. The mean annual temperatures are high, being 27.8 ° C in the capital city of Bamako (Coulibaly, 2003).

Mali has only one rainy season per year. It can cover the period from June/July to September/October in the drier north whereas in the much wetter, southern area, it can start earlier and last until November. Seasonal rainfall also feeds the inner Niger delta, but with a delay for the river crest to reach inland. Some parts of the delta only become flooded during the dry season. The timing and level of flooding are unpredictable for many parts of the delta⁷, depending on the topographical relief and the quantities of rainfall received further south and west.

Arable cropland and continually cropped land accounts for less than 6% of Mali's land area, and forests account for 4% according to estimates (FAOSTAT data). The boundaries between crop- and pasturelands are not clearly defined as land used for cultivating crops or pasture can depend on the rainfall and farmers' needs. Soils in Mali range from sand dunes and sandy or gravelly soils derived from sandstone to fertile alluvial soils in the inner delta region, and heavier silty- and partly lateritic-soils in the Sudanian zone of southern Mali (Coulibaly, 2003).

⁷ https://en.wikipedia.org/wiki/Inner_Niger_Delta (22 March 2017)

Table 2 indicates the relative expected levels of adoption of modern varieties, Figure 5 presents the geographic locations and the rainfall isohyets of the areas selected for this study.

Table 2: The study areas and their relative expected levels of ‘modern’ maize, sorghum, pearl millet and rice variety adoption in Mali.

Level of Adoption	Maize	Sorghum	Rice	Pearl Millet
Higher level	Sikasso	Koutiala	Niono	Ségou
Lower level	Koutiala	Ségou	Mopti (lowland)	Mopti (upland)

Reliable data on crop yields in Mali, disaggregated by regions and smaller administrative units, are hardly available. Published data usually focus on total amount of grain produced by region, rather than yield (with information on production area per crop not being provided).

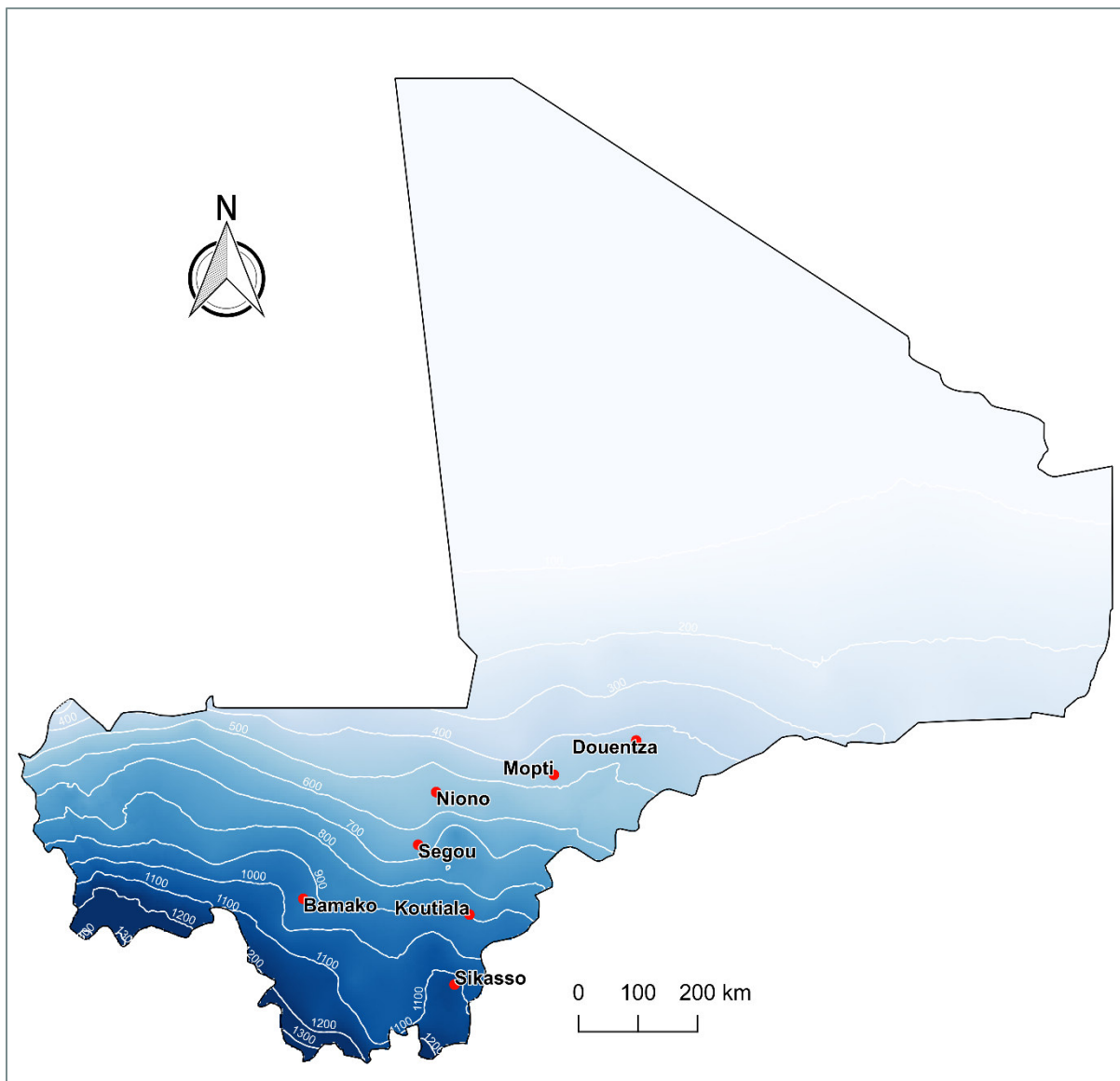


Figure 5: Study locations in Mali with mean annual rainfall isohyets in mm.

Approach and Methodology

A statistical yearbook offers the following information for the year 2015: Maize yield in the entire Sikasso region (to which both selected study areas for maize belong) is 2.7 t/ha, thus slightly above the national average of 2.5 t/ha. Sorghum yields in Koutiala (in Sikasso region) are 1.1 t/ha compared to 1.0 t/ha in the Ségou region, thus close to the national average in both areas (Ministère de l'Agriculture, 2016a).

Rice yields in the Ségou region (with Niono as selected study area for high adoption of modern varieties, see below) are 1.9 t/ha on average, but yields of irrigated rice in Niono reach 6 t/ha (Kater *et al.*, 2000), compared to 2.5 t/ha in the lowlands of Mopti region, which was selected for studying low adoption. The national average for rice in Mali is stated to be 2.5 t/ha. Pearl millet yields in Ségou and Mopti are both around 0.9 t/ha and thus close to the national average (Ministère de l'Agriculture, 2016a). It can be expected that variations in crop yields are in fact larger, depending on variable agroecological conditions within each of the ten regions of Mali, and on production systems, e.g. in the case of rice. Agroecological conditions of the selected study areas are described below in more detail.

The **Sikasso** region, in southeast Mali, receives more rainfall than elsewhere in the country, favoring a highly diverse agriculture. The area around the regional capital, Sikasso (1121 mm rainfall), produces cotton, cereal crops including maize, rice, sorghum, pearl millet and fonio (*Digitaria* millet), pulses like groundnut, soya, and cowpea, as well as sesame, forage crops, potatoes and sweetpotatoes.

Furthermore, fruits, such as mangoes, oranges and bananas, are also cultivated in the Sikasso region (Région de Sikasso, 2007). **Koutiala**, approximately 140 km north of Sikasso, has a lower mean annual rainfall (889 mm) and is a major area for cotton and grain (sorghum, pearl millet and maize) production.

The **Ségou** region, on the dividing line between the Sudanian Zone to the south and the Sahelian Zone to the north, has mean annual rainfalls ranging from approximately 500-700 mm (Ségou: 642 mm; Niono: 548 mm). The rainy season in this region is considerably shorter than in the Sikasso region. However, irrigation is possible in some areas using water from the Niger and Bani rivers. Ségou is an important agricultural region in Mali, producing sorghum, pearl millet, and rice as cereals, as well as groundnuts, horticultural crops and fruits. Furthermore, livestock production and fishery are of significant economic importance. **Niono**, a district in the Ségou region 100 km north of the city of Ségou, is the most important and oldest area for growing irrigated rice, organized by the parastatal Office du Niger (ON) (Région de Ségou, 2011).

The **Mopti** region, part of the Sahelian zone of Mali, has mean annual rainfalls ranging from 300-500 mm (Mopti: 495 mm; Douentza: 449 mm; Youwarou: 353 mm). The majority of the region is upland with dryland agricultural production. About one third of the agricultural land is regularly flooded, while other parts are irrigated (with only partial control) with water from the Niger River (Région de Mopti, 2006). Pearl millet is the most important cereal in the Mopti region, followed by rice, sorghum, maize and fonio. Horticultural crops are also important in some irrigated areas. The level of cereal production varies depending on rainfall conditions. Pastoral and agropastoral livestock production are also of great importance for the region, as well as fishery (Région de Mopti, 2011). The town of **Douentza**, 150 km northeast of the city of Mopti, is the administrative center for the Douentza district, which is part of Mopti region. Farmers between Mopti and Douentza grow pearl millet and or rice, depending on the topography of their land. East of Douentza, pearl millet is the only cereal crop grown.

Interviews were conducted in **Bamako** of staff from the national research programs of IER, the National Agricultural Department, ICRISAT, seed companies, the Green Innovation Center of Deutsche Gesellschaft für internationale Zusammenarbeit (GIZ) and a national farmers organization as well as grain traders and grain processors.

3.2.6 CHOICE OF INTERVIEW PARTNERS

Interview partners were chosen focusing on the different types of actors in the seed systems of the selected crops based on a methodology for stakeholder identification and analysis suggested by Lelea *et al.* (2014). We initially identified ten categories of actors who ‘have their hands on the product’, in this case seed or products derived from seed, fulfilling specific actions that are necessary for a seed system to function (Figure 6). One further category was created for other actors who are involved in other capacities, e.g. as representatives of relevant government bodies, service providers or NGOs focusing on seed and food security issues.

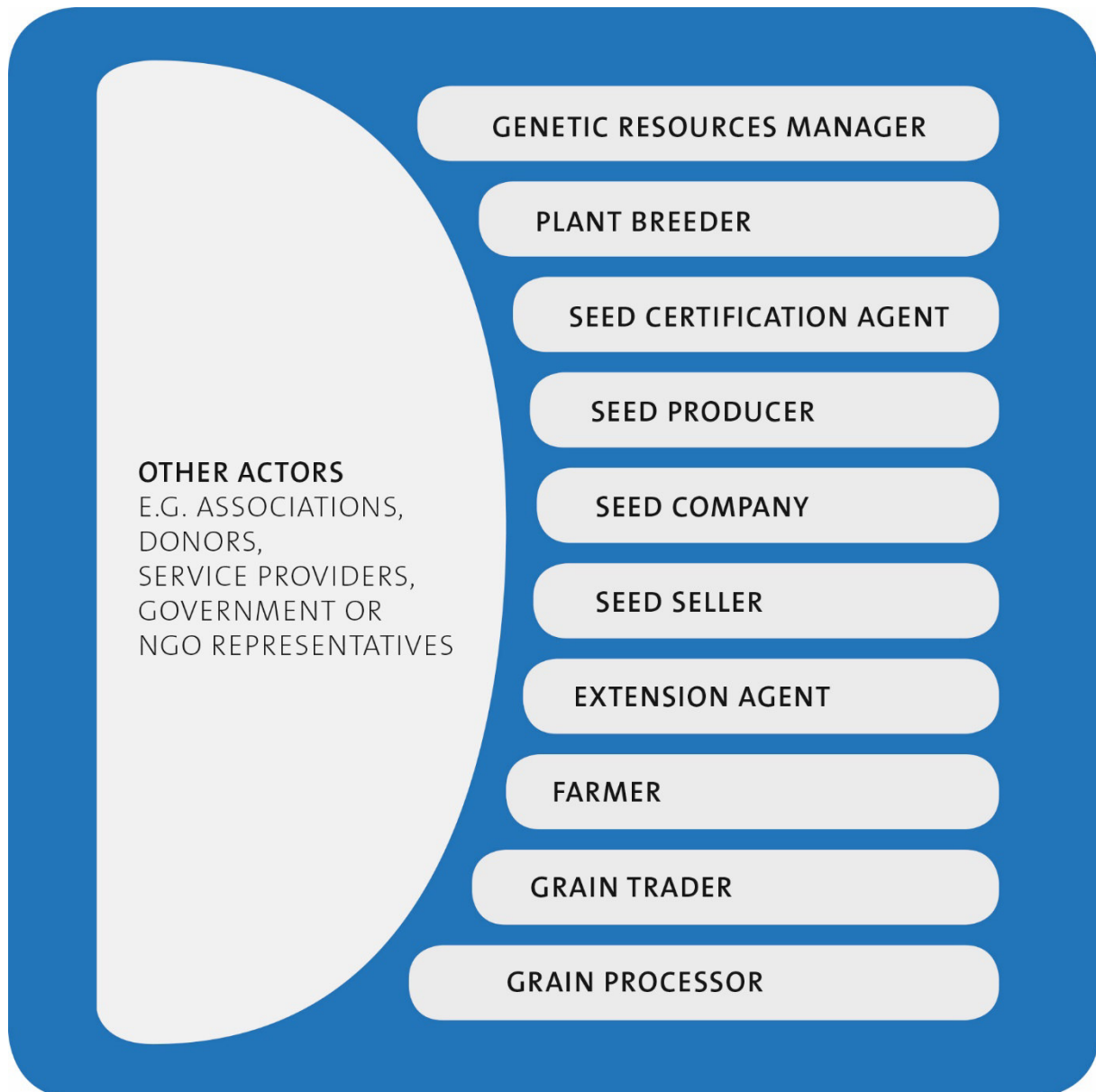


Figure 6: Actor categories identified for selection of interview partners, based on their activities in relation to seed system functions (see Figure 1).

These eleven actor categories are related to the seed system functions that were presented earlier (see Figure 1). As different actor types may be involved in the same major function, for example farmer, grain trader and grain processor are involved in crop production and use, there are more actor categories than seed system functions. We considered extension agents to be actors ‘who have their hands on the product’ and not just service providers, since they are critical for facilitating farmers’ access to seed and may be directly involved in seed

dissemination or collaborative testing with farmers and breeders. Farmer seed-producer cooperatives and associations that operated independently, i.e. without contracts to produce for a specific entity, and sold seed directly to farmers were included under the seed company classification rather than the seed producer category. Seed sellers in this study are those who sell seed to farmers without being directly involved in its production, e.g. agrodealers or local traders.

We identified potential interview partners for each country, study region, crop and actor category based on internet research, existing contacts, or contacts established as the fieldwork developed. Care was taken to include actors with smaller- and larger-scale operations and inclusion of both genders where such factors were relevant, particularly for seed producers and sellers, extension agents, farmers, grain traders and processors.

3.2.7 INTERVIEW METHODS

Semi-structured interviews were used to explore the views and experiences of individual seed system actors of the above-described categories. In some cases, several colleagues, married couples or small groups of farmers were interviewed instead of individuals, depending on the situation. The semi-structured interview method was chosen for exploring actors' perspectives in a qualitative manner as it offers a balance between the advantages and disadvantages of informal, open-ended interviews on the one hand, and formal surveys on the other (Galletta, 2013)⁸.

The method combines a pre-determined set of open questions with the opportunity for the interview discussion to explore in greater depth particular themes or responses. The interviews were conducted in a conversational manner where the respondent had an active role, allowing new issues of relevance to be raised that were not considered *a priori* by the interviewer. The order of questions or topics discussed was not fixed.

Interview guides for each actor group (see Figure 6) were prepared beforehand by members of the study team. One portion of the guide part focused on the actors' activities regarding the varieties and seed sources used, and use of grain produced (for farmers), or varieties and quantities of seed sold (for seed traders), etc. Another set of questions focused on relationships with other actors, and the interviewees' experiences and suggestions for improvement. Very basic information on the scale of activity, sex and location of the interviewees was documented along with each interview.

A total of 119 interviews were conducted in Kenya and 163 Mali. In Kenya, 222 people were interviewed, of which 97 were women (44%). In Mali, 233 people were interviewed, of which 54 were women (23%). A complete list of interviews conducted for the purpose of this study is provided in the Annex. The number of interviews conducted by study region (Table 3) and actor category (Table 4) are presented for each country.

The results were documented by taking notes during the interview on the previously prepared interview guides. Team reflections during the fieldwork lead to a preliminary evaluation of interviews conducted, and helped identify relevant issues raised by the interview partners with regard to the various crops and study regions.

⁸ See also: <http://designresearchtechniques.com/casestudies/semi-structured-interviews/>; <http://evaluation-toolbox.net.au/> (22 April 2017).

Table 3: Number of interviews conducted by study region in Mali and Kenya.

Mali		Kenya	
Study region		Study region	
Mopti	40	Tharaka Nithi	38
Niono	30	Trans Nzoia	27
Ségou	28	Homabay	31
Koutiala-Sikasso	35	Machakos	9
Bamako	30	Nairobi	14
Total	163	Total	119

Table 4: Number of interviews conducted by actor category in Kenya and Mali; some interviews included two actor groups.

Actor Category	Kenya	Mali
Genetic Resources Manager	1	1
Plant Breeder	4	6
Seed Certification Agent	2	4
Seed Producer	5	6
Seed Company	7	24
Seed Seller	12	7
Extension Agent	9	6
Farmer	49	64
Grain Trader	12	16
Grain Processor	2	13
Other	21	21

A preliminary evaluation of the interviews was done for the purpose of this report and as input into the stakeholder workshops. It entailed (a) clearly assigning each interview to an actor category and where relevant separating them within groups according to gender and scale of operation; (b) extracting and summarizing how the statements made by the interviewee relate to various seed system functions (see Figure 1), what they reveal with regard to relationships with other actors and which suggestions for seed system improvement were made. As such, the results from interviews are presented in summarized form in Sections 4.2 and 5.2 for Kenya and Mali, respectively. Regarding preferred varietal traits mentioned in interviews, a semi-quantitative evaluation was conducted, summarizing how often which trait was mentioned as preferred/not preferred by women and men. A more systematic evaluation, including for example differentiation of statements made for other topics among and within actor categories, needs more time and may be envisioned at a later stage.

Since the evaluation was done on a qualitative basis, we report on the full range of experiences and views mentioned. This means that ‘relevance’ is not determined by the number of interview partners mentioning a particular view or experience; even single or dissenting statements form part of the diversity of experiences and views that were reported by seed system actors, and are as such relevant. In the text, we make this transparent by mentioning that a particular statement was made by only one or few respondents. Since the work was intended to yield ‘entry points’ for seed system development and targeted capacity building, quantitative assessments could follow if needed, based on the issues and suggestions identified in this study.

3.2.8 CHOICE OF WORKSHOP PARTICIPANTS

A multi-stakeholder workshop was organized in each country to bring selected seed system actors together for discussions and joint priority setting. The workshops were held in Kenya on 23 and 24 February 2017 at Maanzoni Lodge, Machakos, and in Mali on 17 and 18 March at Hotel Djoliba, Ségou.

The workshop participants were selected from among the interviewed seed system actors, based on the following criteria:

- Coverage of the various actor categories, including people engaged with the different crops and coming from the different study regions.

Approach and Methodology

- Actors of both genders were chosen, as far as possible, to represent relevant actor categories (mainly seed producers, farmers, grain traders and grain processors).
- Individuals who exhibited high levels of engagement and ability to speak up, listen to others and share ideas from each actor category; and capacity to understand a major workshop language (English, French and Bambara) and to speak with aid of interpretation by one of the study-team members.
- Limiting the total number of participants to 25-30 per workshop, including members of the study team, to ensure an atmosphere conducive to discussion and exchange.

Most participants were invited by e-mail and phone with the exception where e-mail and phone contact was not possible or a formal invitation was required, in which case an invitation letter was personally transmitted.

In certain cases the persons invited were unable to attend the workshop and sent a colleague to replace them. Hence, the majority of workshop participants had contributed to the interviews and interacted previously with at least one member of the study team.

3.2.9 WORKSHOP STRUCTURE AND METHODOLOGY

The workshops in both countries were designed along the following lines:

1. The purpose of the study and the workshop were introduced, including the overall approach taken for the study and its focus on seed systems. Seed system functions and the actor categories were described to participants, enabling each participant to see his or her role(s) and what they represent for the workshop.
2. An overview of suggested options for seed system improvement from the field interviews was presented to the participants to include the inputs from all interviewees, lay a common ground, and get feedback from diverse actors.
3. Discussions on possible seed system interventions and improvements were facilitated across and within actor groups to identify priority options for seed sector development.
4. The participants' ranked all suggested options/interventions, first within groups and then, with facilitation, across all workshop participants to identify the highest priority entry points for seed system strengthening.
5. The prioritization outcomes and further aspects of seed system functioning/development were discussed in plenary following each ranking exercise.

A particular challenge for the methodology and facilitation were the participants' different levels of familiarity with written language in general, and different degrees of comfort using English (in Kenya) or French (in Mali) as a common language. Therefore, some discussions were held in local languages and assistance provided to participants by multilingual members of the study team for documenting the results.

Furthermore, care was taken to facilitate discussions in such a way that issues raised as important by certain actor groups could not be simply 'removed' from the agenda by others. In all stages of the discussion, participants were encouraged to propose additional options they felt were missing, to explain ideas behind suggestions they made, or to reflect on the outcomes of priority setting exercises, e.g. on differences among priorities set by various groups.

The Kenya workshop discussions began first with all different actors from each individual county (*place-based discussions*). The next level of discussion was among people of similar actor categories, regardless of location, within three groups: (1) farmers; (2) plant breeders, seed companies and representatives of KEPHIS; and (3) agro-dealers and supporting actors, including extension staff from government and NGOs (*actor group based discussions*). The final discussion session was held in the plenary for joint priority setting among the top three priority options for seed system improvement identified by each of the previous groups (*plenary discussion*).

The first discussion round of the Mali workshop was organized on a crop basis, with crops representing to some extent place-related conditions. Six groups were formed with 3-5 participants each from mixed actor categories,

discussing (1) options for improving the availability of high quality seed close to farmers, and (2) options for improving the adoption of this seed, separately for millet, sorghum and maize, and rice.

For the second discussion round, the groups were re-organized so that people representing closely related actor categories worked together, e.g. farmers, grain traders and processors; seed sellers and supporting staff, e.g. extension agents; breeders, seed companies and seed sellers, and seed producer, seed certification agent and seed trader. Based on priority options suggested after the first discussion round, three of these groups focused on options for ensuring seed quality, one on options for improving benefits from local variety seeds; and two others on exploring options for and advantages of improved collaboration among seed system actors. The final discussion was held in plenary for joint priority setting of the proposed options for seed system improvement.

The final lists of prioritized actions for each country thus represents those actions for which most participants agreed that they had highest priority, and in which many of them were interested. This does, however, not mean that other proposed actions could or should not be followed up by those actors for whom they are relevant. This is why the priorities of the various groups that were formed in the course of the workshop and priorities identified by them before establishing the final list are presented in Sections 4.3 and 5.3 as well.

The workshop results were documented on flip-chart paper and paper cards by the participants and compiled in preliminary workshop reports by members of the study team directly after the workshops had taken place. These preliminary reports were then used as a source for the final project report and are presented in summarized form in Sections 4.3 and 5.3 for Kenya and Mali, respectively.

4 RESULTS OF KENYA CASE STUDY: ECONOMIC AND REGULATORY FRAMEWORK, ACTOR PERSPECTIVES AND PRIORITIES FOR SUSTAINABLE SEED SYSTEM DEVELOPMENT

Our Kenya case study entails three major parts: a compilation of information on economic and trade-related aspects and regulatory frameworks, including the regulatory framework for seed system development (Section 4.1); the results from interviews that were conducted with individual seed system actors (Section 4.2), and the results of a workshop that brought actors from previously described actor categories together (Section 4.3).

4.1 ECONOMIC AND REGULATORY FRAMEWORK FOR SEED SYSTEM DEVELOPMENT IN KENYA

This section provides basic economic information on Kenya's agricultural, food and seed sectors, food and seed aid, and the regulatory framework for the seed system.

4.1.1 BASIC ECONOMIC INFORMATION ON KENYA'S AGRICULTURAL AND FOOD SECTORS

Kenya is a multiethnic country having an estimated population of 46 million people, which increases by approximately one million per year⁹. *Per capita* Gross National Income (GNI) was 1,340 US-\$ in 2015; GNI has increased by about 26% between 1990 and 2015.

The Human Development Index (HDI), a summary measure for assessing progress in three basic dimensions of human development (health, education and standard of living) was 0,555 in 2015, putting Kenya at rank 146 out of 188 countries for which the HDI was assessed (UNDP, 2016a). Kenya is thus considered a 'medium developed', 'middle income' country, according to these assessments. Around 40% of the population, lived below the poverty line in 2015, making Kenya one of the African countries with largest populations living in extreme poverty, in spite of its economic growth (Karanja, 2015).

Maize is by far the most important staple cereal in Kenya, grown on slightly more than 2 million ha annually and total annual production having reached around 3.5 million tons in recent years (average of years 2010-2014, FAOSTAT¹⁰ data). Yield levels of maize in Kenya are around 1.7 t/ha (average of years 2010-2014, FAOSTAT data). Sorghum is grown on around 0.2 million ha annually, with a total annual production of around 170,000 t and yield levels of around 0.75 t/ha (average of years 2010-2014, FAOSTAT data).

Compared to maize, sorghum is less vulnerable to heat and drought (Adhikari *et al.*, 2015) and better adapted to low soil fertility. The relative yield difference between these crops depends on the production conditions. The average maize yield in Trans Nzoia County, for example, exceeded those of sorghum yields nearly threefold (244-312%) whereas in Homabay County they differed only by 6% to 20% in the same 2012-2014 period¹¹. Production conditions also vary within counties (see Section 3.2) such that, in individual farmers' fields with unfavorable moisture or fertility conditions, sorghum can yield more than maize.

Agriculture is often said to be the 'backbone' of Kenya's economy, with about 75% of the population relying on agriculture for livelihood and employment. Furthermore, agriculture contributes about 26% to the country's Gross Domestic Product (GDP) and agricultural produce exports account for nearly two thirds of total domestic export (MoALF, 2016). Agricultural exports entail oil crops and derived products, particularly coconut and macadamia nut, as well as horticultural crops, especially flowers, and so-called industrial crops, e.g. coffee and tea (MoALF, 2016).

⁹ <http://www.worldbank.org/en/country/kenya/overview> (22 April 2017)

¹⁰ <http://www.fao.org/faostat/en/> (15 December 2016)

¹¹ Calculated based on data provided by MoALF (2016)

On the other hand, Kenya is not entirely self-sufficient for staple food crops. Maize imports exceed exports on a regular basis; the same is true for wheat and other staple food crops. Grain importation in the country has had notable annual fluctuations for maize and wheat (Figure 7), whose domestic consumption is much higher than for rice and sorghum. An upward trend, particularly for wheat, may be attributable in part to increasing population and domestic demand. Although a single maize import spike in 2009 followed the post-election violence in 2007/08, increased maize imports of 800,000 to 1 million tons have also occurred for several years in the 2014-2017 period according to various sources. This increased maize importation may be attributable to increasing demand and decline in domestic production due to crop losses from pests or diseases, such as Maize Lethal Necrosis (MLN), as well as erratic rainfall patterns that have recently affected grain production.

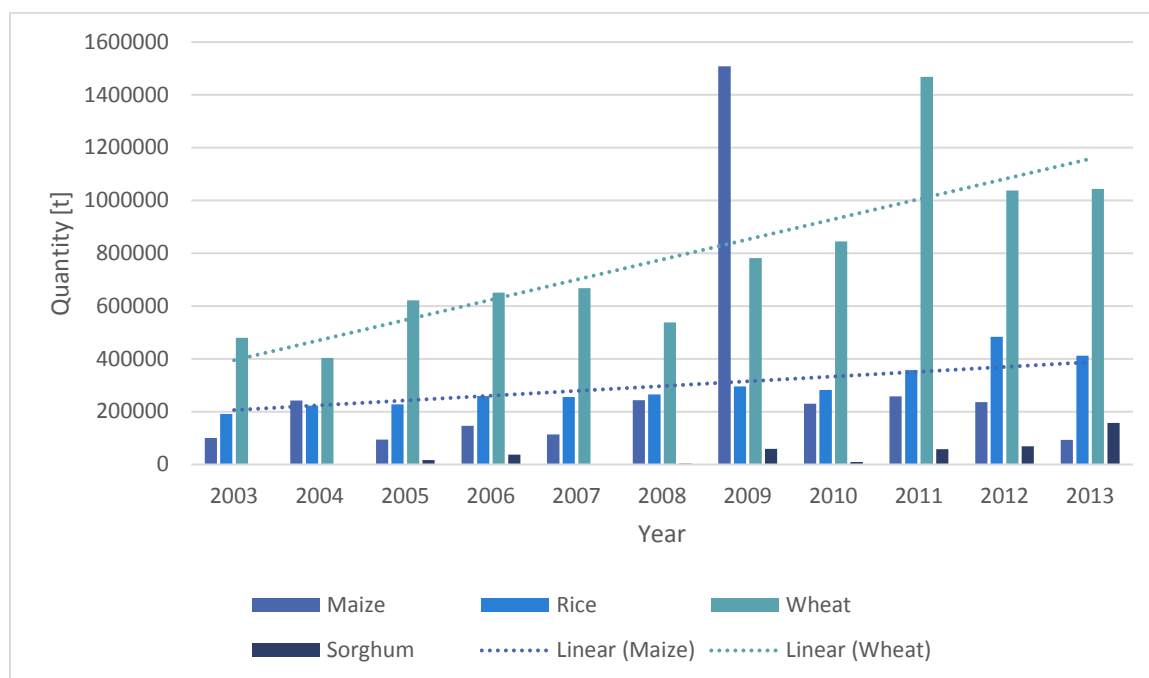


Figure 7: Quantities of grain imports (maize, rice, wheat, sorghum) in Kenya, 2003-2013 (FAOSTAT data).

4.1.2 REGULATORY FRAMEWORK FOR KENYA'S SEED SYSTEM

The regulatory framework influencing seed system development in Kenya depends on its membership in international organizations and treaties, its national legal provisions, as well as policies and sector strategies. These are briefly presented in the following sections along with the procedures for variety release and seed certification.

MEMBERSHIP TO REGIONAL ORGANIZATIONS

Kenya is a member of the East African Community (EAC) and of the Common Market for Eastern and Southern Africa (COMESA), which is in the process of establishing a plant variety catalogue and harmonizing seed legislations among its members. Kenya is also a member of the African Intellectual Property Organization (ARIPO), which is in the process of developing an instrument for the protection of new plant varieties based on the Arusha Protocol, which was adopted by member states in 2015¹², but has so far not entered into force.

¹² <http://www.aripo.org/resources/laws-protocols?download=52:arusha-protocol-for-the-protection-of-new-varieties-of-plants> (22 November 2017)

MEMBERSHIP TO RELEVANT INTERNATIONAL TREATIES

Kenya has been a member of UPOV since 1999 under the 1978 Act of the Convention, and acceded to the 1991 Act in 2016. Furthermore, it is a state party to the Convention on Biological Diversity (CBD), the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA), the Cartagena Protocol on Biosafety and the Nagoya Protocol on Access to Genetic Resources and the Fair and Equitable Sharing of Benefits Arising from their Utilization.

Kenya is also a state party to the International Covenant on Economic, Social and Cultural Rights (ICESCR), which includes, *inter alia*, the right to adequate food and the human right of everyone to benefit from scientific progress and its applications. Both human rights are relevant for the design and implementation of seed-related policies, especially with regard to ensuring vulnerable groups' access to seed and other productive resources (Christinck and Tvedt, 2015).

NATIONAL LEGAL PROVISIONS

The Seeds and Plant Varieties Act 1972 (last amended 2012) establishes the basic rules for variety registration and plant breeders' rights. It mandates KEPHIS to register and protect new varieties of plants in accordance with UPOV requirements and the regulations in the Seeds and Plant Varieties Act (Government of Kenya, 2012a). KEPHIS is thus responsible for variety evaluation, registration and release, plant protection, national listing, licensing and royalty collection. It manages the National Performance Trials (NPTs), including data collection and analysis, publication of approved and released varieties, maintenance and updating of the national variety list index of all registered plant varieties and maintenance of a register of all applications for performance trials. To be registered and added to the national list, a variety must undergo a test for distinctness, uniformity and stability (DUS) and performance trials for at least two seasons.

Genetically Modified Organisms (GMOs) are regulated by the National Biosafety Authority (NBA) in collaboration with KEPHIS under the Biosafety Act of 2009 (Government of Kenya, 2009). NBA is responsible for testing GMOs for release and for preventing the unauthorized use of genetically modified crops. Currently, the Kenyan government does not allow for the importation and use of GMOs. This position is however being renegotiated; the NBA has recently authorized the cultivation of Monsanto's genetically-modified, drought-resistant corn (DroughtGard™) for field trials.

Seed certification is carried out by KEPHIS according to the International Seed Testing Association's (ISTA) rules and standards set by the Organisation for Economic Co-operation and Development (OECD). The certification process includes field registration, seed crop inspection, seed laboratory testing, labelling and sealing, post control, and post certification surveys (see below). Only officially released varieties and breeder's lines which have the potential for being released are eligible for certification according to the Seeds and Plant Varieties (Seeds) Regulations¹³. Seeds are only certified if they have been produced, inspected, sampled, tested and are complying with the standards set out in the Crops Act (Government of Kenya, 2013) and the Plant Protection Act (Government of Kenya, 2012b).

KEPHIS is also the national authority mandated to regulate seed trade. Seed distribution, including import, is open to registered seed merchants. Seed import requires a phytosanitary certificate and an import notification letter from the country of origin, a plant import permit, a notice to import and a seed-testing certificate, as required by the Seeds and Plant Varieties Act Government of Kenya, 2012a).

¹³ <http://www.wipo.int/edocs/lexdocs/laws/en/ke/ke011en.pdf> (22 April 2017)

NATIONAL AGRICULTURAL POLICIES AND SECTOR STRATEGIES

Given the importance of the agricultural sector for Kenya's economy, the Government of Kenya has developed policies and strategies that aim to increase productivity and resilience of the farming sector and address existing challenges. Of particular interest to this study are the policies and strategies that influence the development of seed systems as well as the production and commercialization of cereal grain. The main policy frameworks for agricultural and seed sector development in the country are thus briefly presented in this section.

Vision 2030, 2008-2030: Launched in 2008, its goal is to guide Kenya's transformation into a middle-income industrialized country with a high quality of life for her citizens by the year 2030. It recognizes agriculture as a key sector that will contribute to the realization of at least 10% annually growth of the GDP (Government of Kenya, 2008). To support agricultural development, the Vision 2030 sets out strategies for transforming smallholder agriculture from subsistence to an innovative, commercially-oriented and modern agricultural sector through the following objectives: (1) transforming key institutions in agriculture, livestock, forestry and wildlife to promote agricultural growth; (2) increasing productivity of crops, livestock and tree cover; (3) introducing land-use policies for better use of high-and medium-potential lands; (4) developing more irrigable areas in arid and semi-arid lands for crops and livestock; (5) improving market access for smallholders through better supply chain management; and (6) value addition of farm, livestock and forestry products before they reach local, regional and international markets.

Agricultural Sector Development Strategy (ASDS), 2010-2020: This is the overall agricultural policy and strategy blueprint dedicated to realizing the Vision 2030 objectives. The ASDS is based on two key elements: (1) increasing productivity, commercialization and competitiveness of agricultural commodities and enterprises; and (2) developing and managing key factors of production – farm inputs including seed. The strategy was developed to domesticate the Comprehensive Africa Agriculture Development Programme (CAADP) declared in 2003 under the New Partnership for Africa's Development (NEPAD), with the overall goal to help African countries reach a higher path of economic growth through agriculture-led development, eliminating hunger, reducing poverty and food insecurity and enabling expansion of exports (Government of Kenya, 2010a). Furthermore, the ASDS recognizes the importance of biodiversity and seeks to improve environmental and biodiversity conservation. The ASDS is currently being revised in line with devolution and recent developments in the local and international arenas.

National Agricultural Policy: The new Agriculture Policy has been drafted in line with the new Constitution and will review a number of previous policies. It aims at improving on the gains of the ASDS by outlining guidelines that support realization of ASDS objectives many of which have been devolved and are now functions of the county governments. The broad objective of the Agricultural Policy is to improve food and nutrition security and maximize incomes through optimal utilization of resources in the agricultural sector (Government of Kenya, 2015). This entails, *inter alia*, promotion of 'best practices' and consolidation of land for agricultural production, including by relocation of settlements and discouraging subdivision of land into economically unviable units¹⁴.

National Seed Policy (2010): The National Seed Policy recognizes the importance of seed for increasing agricultural productivity and enhancing food security. The strategy paper stresses the need to review seed-related policies and the legal framework to ease the access to high quality seeds by farmers (Government of Kenya, 2010b). The strategy's goals include enhancing the potential for improved varieties and technologies for increased agricultural and forestry productivity; effective regulation, coordination and management of all activities within the seed subsector in order to tap synergies; enhancing efficiency and eradicating prevalence of adulterated seed;

¹⁴ <https://www.standardmedia.co.ke/mobile/article/2000173214/policy-proposes-moving-kenya-s-rural-population-to-towns-to-pave-way-for-food-growth> (21 July 2017)

building capacity and infrastructure within the seed subsector to handle research and development, quality control, technology transfer, conservation and preservation of germplasm and other emerging technologies, e.g. GMOs; harmonizing regional seed policies and regulations to enhance cross-border trade and to monitor seed supply and demand situations in order to ensure adequate strategic seed reserves (Government of Kenya, 2010b).

National Food Security and Nutrition Policy (2011): The policy provides an overarching framework covering the multiple dimensions of food and nutrition security in Kenya. Its entry into force was meant to add value and create synergy to existing sectoral and other initiatives of government and partners in addressing food insecurity and malnutrition affecting millions of Kenyans. The policy recognizes the need for multi-public and private sector involvement, and that hunger eradication and nutrition improvement is a shared responsibility of all Kenyans (Government of Kenya, 2011). To achieve food sufficiency, the policy supports increased production of adequate quantities of food items such as grains. In this regard, the policy, if fully implemented, will increase commercialization of seed used for production of grains and other food commodities.

National Agricultural Sector Extension Policy (NASEP) (2012): This policy was formulated to address numerous challenges associated with weaknesses of the agricultural extension system in the country, which plays a significant role in the adoption of improved seed for grain production by the farmers. As such, extension directly affects how seed industry can commercialize seeds. The NASEP includes provisions for harmonization, quality control and regulation, for improving stakeholder linkages as well as for mainstreaming cross-cutting issues in 'extension messages' (Government of Kenya, 2012c)

National Agricultural Research System (NARS) Policy (2012): The policy was developed to streamline, rationalize and put in place a system that is consultative, efficient and effective and takes into account economies of scale that use current scientific, human and physical capacities, and position Kenya as a hub for agricultural research and development in the region (Government of Kenya, 2012d).

Other policies supporting agricultural development in the country with particular emphasis on development and adoption of 'improved' seeds by the farmers include the **National Cereal Crops Policy**, the **National Agro-chemical Policy**, the **Livestock Feeds Policy**, the **Agricultural Sector Youth Policy**, the **National Agricultural Insurance Policy**, the **Cooperative Development Policy**, the **Devolution Policy**, the **National Irrigation Policy** and the **National Policy on Disaster Management**, among others. In addition to the ASDS, the government has developed other commodity plans and strategies to actualize the policies discussed above, most of which are currently under implementation. These include the **National Climate Change Response Strategy** (2010), the **National Agribusiness Strategy** (2012), the **Economic Recovery Strategy for Wealth and Employment Creation (ERSWEC)** (2003-2007), the **National Wheat Development Strategy**, the **Poverty Reduction Strategy Paper** (2001-2004), the **National Climate Change Action Plan** (2013), the **National Action Programme to Combat Desertification** (2002), and the **Flood Mitigation Strategy** (2009), among others.

Furthermore, the implementation of the **Fertilizer Subsidy Programme** and the **National Agricultural Input Accelerated Access Programme (NAIAAP)** that has been supporting resource-poor smallholder farmers to access farm inputs, such as fertilizers and seed, using input vouchers, have influenced the development and commercialization of seed in the country.

VARIETY RELEASE PROCEDURES FOR MAIZE AND SORGHUM IN KENYA

Release of maize varieties is done under Kenya's national maize breeding program, which follows the procedures established by law (see above). The procedures for release of sorghum are similar to those of maize varieties. They entail the following (Government of Kenya, 2016; Sikinyi, 2010; Setimela *et al.*, 2009):

Breeding stage where the plant breeders develop new varieties with desired performance attributes such as resistance to drought, high yields, adaptability to different agroecological zones, time taken to maturity and re-

sistance to different diseases/pests among others. Breeding is carried out by researchers from the national research organizations as well as private seed companies; in the case of foreign seed companies, the breeding itself takes place in other countries and developed products are then taken through the variety release process in Kenya.

Multi-Environmental Trials (METs) are carried out on the developed varieties at on-farm level by the researchers for at least four seasons in at least ten locations. The aim is to identify the superior varieties with good agronomic traits.

Application for registration: The researchers will then apply to KEPHIS for registration of superior varieties identified from the METs. They also have to submit data from their on-farm trials alongside the request to KEPHIS.

National Performance Trials (NPTs): KEPHIS will subsequently subject the varieties received from the breeders to its own independent field testing through the NPTs for further evaluation of the varieties. This is done to test for DUS and Value for Cultivation and Use (VCU) of the varieties before registration. The DUS and the VCU tests are carried out for two to three seasons under rain-fed conditions or two cropping cycles under irrigated conditions. The tests are carried out according to the UPOV protocols and can take between one and three years before sufficient data are available for variety registration.

Approval: KEPHIS will then submit the data from the DUS and VCU tests to the National Performance Trials Committee (NPTC), which comprises of stakeholders in the seed sector chaired by KEPHIS. Based on the data submitted, the NPTC makes its recommendation as to whether or not the variety should be approved for full release, pre-release or rejected.

Registration: KEPHIS will submit the recommendations of the NPTC to the National Variety Release Committee (NVRC) for the registration of the successful varieties. The registration establishes legal ownership of the new varieties.

Release: The National Variety Release Committee will then evaluate the recommendations of the NPTC and the results of the DUS testing and make recommendations to the Ministry of Agriculture, Livestock and Fisheries (MoALF) for release of the varieties. The Ministry will review the recommendations from the National Variety Release Committee and authorize release of the successful varieties.

Entry in National Catalogue: The released varieties are then entered into the National Crop Varieties Catalogue. After successful registration and release of the variety, multiplication and marketing can start.

SEED CERTIFICATION

Seed certification is a process aimed at ensuring that farmers receive seed of defined technical quality, e.g. in terms of trueness to variety, germination capacity, purity and vigor. Seed certification is also an essential tool for trade in the seed sector. The procedures followed in seed certification include the following (Sikinyi, 2010):

Registration of seed merchants and growers: Companies interested in venturing into the seed business must apply for registration with the government through KEPHIS. On the same note, persons interested in seed production must register with the seed companies and seed merchants to be able to access early generation seed. Prescribed documents of proof are issued upon registration.

Proof of origin of the parental materials for seed production: The applicant must provide proof of origin of the variety and crop that they intend to grow. Only registered seed growers contracted by registered seed merchants can grow seed for certification.

Field inspection: An approved seed grower is supposed to make an application to the certifying agency, KEPHIS, to go and carry out field inspection of the planted seed. The inspection process entails an examination of a seed

Results (Kenya)

field for conformity to laid out standards established by the provisions of the Seed Act; e.g. minimum isolation distance, total planting area, trueness to variety (including off-types and foreign varieties), proper detasseling in the case of hybrid maize, proper crop management, and diseases and pest occurrence. Field inspection is mainly carried out during flowering, maturity and harvesting stages.

Traceability tracking: Raw seed from approved farmers' fields must be tracked to maintain traceability. Seed merchants must get a transport order (SR 7) from KEPHIS to enable them to transport the seed from the growers.

Factory processing: This process is carried out after seed harvesting. It involves checking the seed delivered for cleanliness, lot examination and seed sampling.

Seed testing/analysis: This is a laboratory process which entails a number of activities, including verification of the received samples, purity analysis, viability tests (through germination and tetrazolium tests¹⁵), analysis of moisture content, and phytopathological tests to detect relevant seed-borne diseases.

Labeling and sealing: This process entails tagging every seed lot with a label and a seal as required by law in order to ensure that the seed cannot be tampered without damaging the seal, label or container beyond repair.

Post control: This process is carried out to ascertain that the preceding control measures of the seed certification have been effective. It involves the growing of plants from seed lots which have been certified to further determine and confirm cultivar or variety purity and freedom from seed-borne disease. Samples of the certified seed lots are grown out in the field, alongside the known true representative of the variety, to evaluate their performance. These tests aim to ensure that varietal characters remain unchanged during seed multiplication.

Post-certification surveys and licensing of seed stockists: The process is carried out by KEPHIS which is required by law to carry out sampling and testing of seeds stored for sale by licensed sellers on an annual basis. The licensing grants them the right to sell certified seed.

Seed merchant registration: KEPHIS is required by law to register as seed merchant any person who applies to be registered to produce, process and/or market certified seed.

4.1.3 STRUCTURE AND ESTIMATED SIZE OF MAIZE AND SORGHUM SEED MARKETS (KENYA)

With a total maize production area of 2 million ha (see above), the amount of maize seed required for sowing would be around 40-50,000 t (calculated with sowing rates of 20-25 kg/ha). For sorghum, with 0.2 million ha, the amount of seed required for sowing would be around 1,000-1,600 t (calculated with 5-8 kg/ha). Although information on the total amount of certified seed produced and sold in Kenya is not publicly available, some information was kindly made available by KEPHIS for the purpose of this study (Table 5).

The data presented in Table 5 show that there is some variation among years for the amounts of locally produced and imported certified maize and sorghum seed, but no clear upward trend for the past decade. For sorghum, there were sudden rises in the amount of locally produced certified sorghum seed in some years (2008/2009 and 2010/2011), followed by a decline to previous levels (or below) in subsequent years.

¹⁵ The tetrazolium test is a quick laboratory test for seed viability.

Table 5: Amounts of locally produced and imported certified seed available in Kenya for the period 2006/2007 to 2016/2017 (Source: KEPHIS).

Year	Certified maize seed [t]		Certified sorghum seed [t]	
	Locally produced	Imported	Locally produced	Imported
2006/2007	35,414.5	3,177.8	544.7	3.0
2007/2008	26,655.0	2,670.7	451.8	-
2008/2009	25,148.0	1,930.3	1,649.2	-
2009/2010	27,880.2	3,022.9	267.4	-
2010/2011	30,638.7	4,669.5	3,204.6	65.0
2011/2012	36,577.6	4,176.1	221.9	120.0
2012/2013	31,187.8	4,061.5	524.1	9.0
2013/2014	28,363.6	2,757.4	239.1	2.0
2014/2015	28,521.3	4,946.8	164.3	15.8
2015/2016	26,805.9	4,977.1	557.3	0.1
2016/2017	32,006.1	4,530.1	398.2	9.4

However, these figures provide only a rough estimate of the amount of certified seed that is actually used by farmers, since Kenya also exports seed, for example 2,761 t of maize seed and 151 t of sorghum and millet seed in 2015/16 (KEPHIS, 2016). Furthermore, re-sampled seed, e.g. after expiry of the previous certification, is another category of seed that contributes in some years more to the total quantity of certified seed than imported seed, thus indicating that parts of the certified seed are not sold in the agricultural season following certification (KEPHIS, 2016).

Based on the amounts of domestic, imported and recertified maize seed sampled (totaling 33,443 t), minus exported seed, we estimate that the amount of certified maize seed available in Kenya totaled 30,682 t in 2015/16. This quantity would be sufficient for sowing around 60% of the cultivated area of this crop (calculated with 25 kg seed/ha). The estimated amount of certified sorghum seed available in Kenya (628 t domestic, imported, plus recertified seed sampled minus exported seed) was 477 t in 2015/16, sufficient for sowing 30% of the area grown with this crop (calculated with 8 kg/ha)¹⁶. These estimates correspond with those given by experts interviewed in the course of our study, and those reported in the literature (see AgriExperience, 2012); Smale and Olwande, 2014). Thus, all other seed used by farmers for sowing these crops is uncertified seed from farmer-managed, local seed systems (= ca. 40% for maize and 70% for sorghum).

The number of registered seed companies in Kenya, including seed producers, processors and sellers, increased from 18 in 1996 to 73 in 2010 (Misiko *et al.*, 2011), and again from 98 in 2011/2012 (KEPHIS, 2012) to 135 in 2015/2016 (KEPHIS, 2016). However, a large share of the registered seed companies seems to be inactive or trade in exports, including seed and planting material of horticultural plants, e.g. flowers. Only 14 registered seed companies actually sold seed of food crops in Kenya, according to a survey on Kenya's seed industry (AgriExperience, 2012); these companies trade in seed of cereals, oil crops, pulses, pastures, fruits and vegetables — mostly crops which also dominate research in relevant public institutions (Misiko *et al.*, 2011).

¹⁶ All figures in this paragraph calculated based on information provided by KEPHIS (2016)

While the first stage of adoption of maize hybrids occurred before 1990 in many regions of Kenya, the second stage (i.e. replacing 'old' hybrids with recently released ones) shows little progress, with the average 'age' of varieties being calculated as 17.6 years across all regions for 2010 (Smale and Olwande, 2014). Private companies have not been active or successful in releasing varieties of staple food crops in Kenya, except for maize. Varieties of other staple food crops, e.g. sorghum, wheat, rice and pearl millet, were all released from public breeding programs (AgriExperience, 2012).

panies) as 'key players' besides KSC. For hybrid maize, 83% of all hybrid maize growers planted seed marketed by KSC, according to a survey conducted in 2010. The remaining 17% of hybrid seed planted were from private companies — including, in order of greater frequency, Western Seed, Pioneer, Monsanto, Pannar, Agriseed, Lagrotech and Faida (Smale and Olwande, 2014).

A specific feature of Kenya's seed market is that one parastatal company, KSC, holds a market share of about 70-80%, mainly based on one hybrid variety of maize (H 614) and one wheat variety ('Kenya Kwale'). Both varieties were developed more than 25 years ago and are more popular among Kenyan farmers than any other single variety of these crops (AgriExperience, 2012; see box).

Hence, although the number of seed companies in Kenya has increased, their presence and market shares are limited compared to KSC. For the entire seed market, not focusing on maize alone, AgriExperience (2012) presents Pannar (based in South Africa), SeedCo (based in Zimbabwe), Monsanto and Pioneer (both multinational companies)

4.1.4 FOOD AND SEED AID (KENYA)

Kenya received food aid via the World Food Program (WFP) in each of the last ten recorded years (2006-2015; FAOSTAT data). In cooperation with the Government of Kenya, the WFP provides school meals for children in the

Food and seed aid are often provided as a package to the same beneficiaries, based on an assumption that food insecurity and seed insecurity are inter-linked, which however is not necessarily the case (McGuire and Sperling, 2011). Moreover, distributed food grain can subsequently be used for sowing by the recipients. Some organizations provide food aid rations to prevent poor farmer families from consuming or selling their farm-saved seed in emergency situations ('seed protection rations'). For these reasons, amounts of food aid provided and distribution pathways used can be of interest for assessing their potential influence on seed systems.

arid and semi-arid regions of northern Kenya and in slum areas of Nairobi, supplementary food for pregnant and nursing women of vulnerable groups, and further provides food assistance to refugees living in some large camps in southern Kenya¹⁷. Via the 'Food for Peace' program, WFP further supports food insecure Kenyans by providing cash or food in exchange for work. These types of food aid interventions are not likely to exert a major influence on maize and sorghum seed systems in Kenya.

Direct Seed Distribution (DSD) is the dominant approach to seed relief in Kenya. DSD is a supply-side approach, where the implementing agency decides what quantities of which crops and varieties to purchase and to distribute as a package to farmers.

¹⁷ <https://www.wfp.org/node/3497/2608/279525> (22 July 2017)

Before devolution¹⁸, the national government, the Food and Agriculture Organization (FAO), and NGOs were involved in DSD. After devolution, county governments have also become involved in DSD, while the national government has been slowly withdrawing from DSD except in cases of serious drought. The transport and distribution of the seed is usually undertaken by the seed companies in cooperation with local government authorities (for distribution), or by NGOs who may already be engaged in distributing other relief supplies (food and non-food) in the target region.

Direct Seed Distribution (DSD) appears to be of interest to seed companies as they can sell large quantities of seed to implementing agencies without any, or with only limited, cost and effort for marketing or customer acquisition. Therefore, the contribution of DSD to sustainable seed system development is questionable.

The major share of seed distributed is usually maize seed, sometimes along with seed of beans, other pulses and vegetables (Sperling, 2001). Seed distributions in the past were usually concentrated on certain regions, where DSD then became part of farmers' strategies for seed procurement (Sperling, 2001). Information on quantities that were distributed is scarce and does not appear fully reliable; complete datasets for longer periods with clear indication of sources are not available.

Among the counties targeted in this study, in recent years, in Homabay County, seed of maize and sorghum was distributed by the national government, county government and NGOs. In Tharaka Nithi County, only the county government (and possibly NGOs) distributed free seed.

An assessment of seed system security (SSSA) in Eastern and Coastal Kenya revealed that seed availability *per se* was not identified as a major problem in any of the assessed sites, even after a drought season (USAID/OFDA, 2011). The overall demand for seed was met; only for crops other than maize, preferred varieties were not always on offer. However, individual farmers' access to certified seed, which was 200-500% more expensive than seed from local sources, was an issue across sites; the reasons varied among sites and groups of farmers; even though farmers purchased more seed than in normal years to compensate for low stocks, most problems were found not to be caused by the acute situation (drought), but linked to chronic problems (e.g. geographical distance to selling points, large size of packages, improved varieties not available for all crops, general insecurity, etc.) (USAID/OFDA, 2011).

4.2 RESULTS FROM INTERVIEWS WITH INDIVIDUAL SEED SYSTEM ACTORS IN KENYA

The results from interviews with individual seed system actors are summarized here according to the five seed system functions introduced in Figure 1: provision of a legal framework (4.2.1); variety development (4.2.2); seed supply (4.2.3); seed dissemination (4.2.4); and crop production and use (4.2.5).

4.2.1 ACTOR PERSPECTIVES ON THE LEGAL FRAMEWORK (KENYA)

Some seed system actors are involved in the implementation of the legal framework, as executor or customer, when it comes to variety registration and protection, or seed certification. The individual interviewees generally

¹⁸ 'Devolution' in Kenya is a process aimed at decentralizing of government resources and functions, while creating a new layer of administration ('counties'). The devolution is based on promulgation of Kenya's constitution in 2010, and was officially launched through the elections of county governments and assemblies in March 2013 (<http://www.worldbank.org/en/country/kenya/brief/kenyas-devolution>, 22 April 2017).

Results (Kenya)

approved the way the trials (NPTs) for VCU and DUS are conducted and how the decisions about release of individual varieties are made and communicated to the applicants.

Serious concerns were frequently raised regarding the costs, both monetary and time delays, caused by the highly regulated system. Certain breeders indicated that they delayed submitting new varieties for testing until they had sufficient funds to cover costs for the full procedure. Also, certain breeders indicated that KEPHIS would block all KALRO releases when any of the KALRO Centers had serious arrears in payments. Private seed companies voiced concern that this process is too long and it significantly delayed new varieties reaching the market, with seed multiplication only starting once the hybrid was officially released (as the required seed certification is only possible after release; and for hybrids the lag in building up sufficient seed is even greater as the parents must first be multiplied prior to production of the final hybrid seed).

Smallholder farmers did not appear to be well informed about seed regulations and controls. As such they did not directly mention specific concerns, yet their interest in access to, and purchase of, local maize and sorghum varieties does conflict with Kenyan seed regulations, as certification of these (non-released) varieties is impossible and commercial seed activities are illegal.

Seed certification agents reported no major issues with the implementation of the seed certification procedures, except that it was not always easy to get the necessary funding for traveling to far-away seed production sites (see below under 'seed supply'). The outcomes in terms of seed quality from the farmers' perspective are also described below under 'seed supply'.

4.2.2 ACTOR PERSPECTIVES ON VARIETY DEVELOPMENT (KENYA)

The seed system function 'variety development' entails genetic resources management, breeding and release of varieties. The Genetic Resources Research Institute (GeRRI), a division of KALRO, manages maize (approx. 1500 accessions) and sorghum collections (approx. 3000 accessions) with material originating from Kenya. The main activities are the conservation of this germplasm, as well as some characterization. At present, efforts are underway to develop a user-friendly interface so that data about the accessions can be accessed by potential users. GeRRI is also involved in activities that address *in situ* conservation and use of local germplasm, targeting improved nutrition, marketing as well as yield stability. In collaboration with ICRISAT, a recent sorghum collection was conducted in Homabay, Busia, Siaya and Bomet counties. Some of the KALRO breeding programs maintain their own working collections of genetic resources at their station, e.g. Katumani for sorghum. ICRISAT maintains a global sorghum germplasm collection, which contains collections from Kenya. Seed of these collections are available to interested users.

In farmer-managed systems, genetic resources management and breeding are closely interrelated. Many Kenyan farmers continue to practice selection of maize in their fields while saving seed for sowing in the next season, with the frequency being higher in areas with less use of purchased seed. However, even in areas where the use of commercial seed is widespread, particularly small-scale farmers select maize seed from their own harvest, mostly of local varieties.

Sorghum farmers frequently maintained and exchanged their local varieties, which cover a broader range of diverse grain, panicle and plant types than the improved varieties. The local varieties include some that are 'ra-tooned' between the short and long rains, and are thus used for erosion control and animal fodder.

Farmer seed selection is done in fields sown with either local varieties or purchased seed for maize as well as sorghum. The farmer practice of selecting seed to maintain and possibly enhance the performance of local maize varieties is common in Kenya and is expected to contribute to the development of genepools of locally adapted maize populations with preferred grain quality.

Certain NGOs are involved in supporting farmers in these on-farm seed selection practices. A branch of the international catholic aid agency CARITAS at Meru (eastern Kenya) is training farmers on seed selection of sorghum,

pearl millet, cowpea, and green gram. The NGO Rural Initiative Development Programme (RIDEP) has been involved for many years with some farmer groups for establishing and maintaining community seed stores. However, the 'Association Store' of saved seed is not necessarily secure, as was the case with the one in Marimanti, where it was necessary for the members to go to market to purchase grain for use as seed due to the previous season drought and crop failure.

Science-based maize and sorghum breeding in Kenya is mainly the responsibility of KALRO, which is structured by research institutes, such as the Field Crops Research Institute, or the GeRRI. Each institute may manage a number of centers with corresponding research stations and substations for field and laboratory research. Maize and sorghum improvement is conducted within the Food Crops Research Institute, with its seven centers in different agroecologies across the country. Maize breeding efforts target specific agroecologies, such as highland, mid-altitude or coastal areas. Individual maize breeders, based at specific centers or stations, are responsible for breeding new varieties, primarily hybrids, for their specific target ecologies. A total of 13 academically trained staff (BSc, MSc, PhD) work on maize breeding at the different stations of KALRO's Food Crops Research Institute. Sorghum breeding at KALRO is based at the Katumani Center and is guided by one breeder.

The maize breeding efforts in Kenya receive capacity building support from CIMMYT in Nairobi and contributions of germplasm from the International Institute of Tropical Agriculture (IITA) maize program. CIMMYT has established a facility at KALRO for creating maize double haploids, specifically supporting identification of drought-tolerant and nitrogen-efficient maize, while keeping MLN, a disease caused by a combination of two viruses, at bay. Sorghum breeding is supported by ICRISAT, based in Nairobi.

Kenyan maize breeding has collaborated with CIMMYT through programs on insect resistance, drought tolerance and nutrient efficiency over the past ten years. The Alliance for a Green Revolution in Africa (AGRA) has focused support on specific breeders in the national program, targeting the development of maize hybrids for specific agroecologies and traits. Hybrids have thus become available for areas where hybrid adoption was previously low.

While maize is a fairly new crop in Kenya¹⁹, hybrid maize breeding has a long history in the country. The first hybrids were developed before independence²⁰ for the highland areas, where commercial maize farming was already common at that time. A wide range of different types of hybrids are in use now, including hybrids between two populations or open-pollinated varieties (OPVs), top-cross hybrids, double-cross, three-way and single-cross hybrids.

The KSC was founded by a group of commercial farmers in the highlands in the 1960s and evolved into a parastatal company with near monopoly status during the 1980s. Liberalization of the seed market created new opportunities for maize breeding enterprises. International companies, such as Monsanto and Pioneer, or regional ones, such as SeedCo and Pannar Seed (see Section 4.1.3), may release varieties they import from outside of Kenya. The only Kenyan companies that invest in their own maize breeding efforts are the parastatal KSC and more recently an emerging program in Western Seed Company Ltd., with clear success in specific target ecologies.

Sorghum breeding in Kenya is mostly conducted by national public sector researchers at KALRO and universities. The breeding programs at Rongo University and Eldoret University focus specifically on sorghum farmers' needs in Western Kenya for whom sorghum continues to be important for food security, especially for farmers with acidic soils. The KALRO sorghum breeding, conducted in Katumani and south of Katumani, focuses on breeding

¹⁹ Widespread adoption of maize has occurred since the late 19th century under British occupation.

²⁰ Kenya attained independence in 1963.

for the drier regions in central and eastern Kenya where sorghum production complements or replaces maize in the production system.

The ICRISAT-Kenya sorghum breeding program, although mostly focused on regional breeding and coordination, has recently released a series of new varieties in cooperation with KALRO, another university and private sector companies. These materials include sweet-stem sorghum lines. Sorghum breeders would like to develop varieties to capture other market opportunities for sorghum e.g. fish feed, or dual purpose for grain and quality fodder for dairy production in Western Kenya, while improving adaptation to multiple stresses (e.g. acid soils, *striga*²¹, low phosphorus availability). However, public funds for sorghum breeding are extremely limited. Sorghum breed-

The maize variety list is long, with 303 varieties and hybrids listed, many being from recent years. 93 varieties were released in the last five years alone, with releases by KALRO, CIMMYT, some Kenyan Universities as well as nine private companies, including Kenya Seed Company. For sorghum the list includes 20 new releases in the past five years, most of which happened in 2016. They do include the first hybrids. Three private companies released sorghum varieties, including Kenya Seed Company. Public sector sorghum variety releases come from KALRO, ICRISAT and two universities. The limited cultivation or absence of these new varieties in the market, however, is another matter which is addressed in section 4.2.4 under seed dissemination.

ers did not mention selection being conducted for other traits that were important to farmer, e.g. less susceptibility to bird damage or grain weevils (see also below; Section 4.2.5).

To summarize, public and emerging private breeding is considerable in Kenya, particularly for maize, and national breeders are actively collaborating with international research organizations. However, the diversity of production environments, each requiring specifically adapted varieties, spreads the maize breeding thin, with at most only a single program per major production system.

Funding limitations were indicated as seriously constraining the scale and scope of what the programs can address. The dependence of the KALRO breeding programs on project funding was reported to seriously limit their ability to set breeding priorities on their own. One breeder

mentioned having worked on striga resistance but was forced to drop this by the donor supporting the maize breeding program. The breeders interviewed indicated some, but limited, breeding for post-harvest traits, such as grain mold resistance, grain storability and food processing qualities desired by users (section 4.2.5). There was no mention of any breeding specifically targeting smallholder farmers' or women's varietal needs, such as adaptation to low soil fertility.

Furthermore, local efforts to maintain or improve local varieties were not supported by public breeding programs; if such activities were reported, they were mostly sustained by NGOs.

Materials developed by CIMMYT or ICRISAT are either released directly, in collaboration with the national program, or by private sector companies. Private companies may invest in submitting new maize or sorghum hybrids, or varieties into the NPT system for release, and thus obtain authorization for marketing the seed. Kenyan companies felt disadvantaged compared to regional or international companies that can release varieties in other countries with less restrictions, faster or in a simpler process.

All in all, the variety release process functions fairly well in the opinion of most interview partners — as long as fees are paid. Some public sector breeders reported that the high fees for varietal release testing hinder or slow

²¹ *Striga* is a genus of parasitic plants causing severe crop loss in cereal plants under low soil-fertility conditions, and is thus a constraint for resource poor farmers.

While maize breeding in Kenya initially focused on the highland areas, where agricultural intensification is profitable, new hybrids and varieties released over the past ten years show at least eight distinct target ecologies, and include descriptions of the areas for adaptation for each hybrid. These results indicate that breeding efforts have been more agroecologically targeted over the past years.

down the release of new varieties. Some breeders even refrain from submitting entries until funding for the whole procedure is assured. KALRO breeders indicated that if one branch of the institute fails to pay KEPHIS fees, all materials submitted by the entire institute are blocked until the payment is made.

The National Variety Release Committee (NVRC) communicates the NPT results and release decision to the submitting breeders. The results are considered 'sensitive' to the success of private breeding companies, and are thus not released

to the public, even though the process is intended to provide a public service for consumer protection.

The released varieties are registered in the National Variety List, published by KEPHIS, which is accessible by internet. The variety descriptions included in this catalogue tend to be minimal, e.g. *"Early/drought tolerant, adapted to 750-1750 m a.s.l., time to maturity 2.5 months"*. More details describing the adaptation range of new varieties is included in the list since 2010.

4.2.3 ACTOR PERSPECTIVES ON SEED SUPPLY (KENYA)

The viability of a commercial seed system depends on its ability to supply seed offering value to users (addressed in section 4.2.5) and providing a stream of new varieties. In order to reach this goal, the seed system function 'seed supply' is of great importance. It relies on activities such as provision of early generation seed, seed production and quality assurance, e.g. certification

EARLY GENERATION SEED

The first steps for initiating seed production of a newly released variety is the production breeders' seed and basic or foundation seed, referred to collectively as 'early generation seed'. The production of breeders' seed is the responsibility of the maize or sorghum breeder who maintains the newly released variety or the parents of a hybrid. Usually one sample is deposited in the genebank for long-term storage, while the breeder launches maintenance breeding for breeders' seed production.

Early generation seed production of varieties developed and released by the public sector, e.g. KALRO, a Kenyan university, CIMMYT or ICRISAT, can only be initiated when it is clear who covers which costs and receives which revenues during the 'lifetime' of the variety or hybrid. CIMMYT and ICRISAT appear to have clear policies and procedures for licensing. In the case of CIMMYT, exclusive licensing is possible. Private companies can access the released or pre-released materials, get them released and initiate commercial breeders' seed production.

KALRO commonly gives licenses for specific varieties and hybrids, including exclusive licenses, to private companies. The procedures for granting licenses, receiving royalty payments, and covering costs for early generation seed production were reported to be unclear and vary across the organization. This leads to prolonged negotiations, frustrated partners and generally delays seed of new publicly bred varieties reaching farmers. These types of problems were mentioned by all KALRO breeders we interviewed.

A more recent development for the country's early generation seed has been the founding and financing of a start-up seed company that focuses on production and maintenance of early generation seed for the different public and private seed sector producers. Funded and supported by partners such as Bill & Melinda Gates Foundation (BMGF) and African Agricultural Technology Foundation (AATF), the company is expected to contribute to a reduction in the cost of production and maintenance of early generation seed for public and private seed sector producers alike.

AGRA has employed one person specifically to assist with negotiations between KALRO and private seed companies interested in licensing a KALRO variety or hybrid. KALRO, with donor support, has started a stakeholder discussion process to improve the clarity and transparency of the process and to reduce the time to finalize and implement it. As this stakeholder process was recently started and is ongoing, we did not invest further effort to study this in detail.

KALRO also has its own seed unit which markets seed directly. The primary purpose is to produce early generation seed of KALRO-released hybrids for sale to the private sector. A second objective is to make seed available of crops and varieties in which the private sector is not inter-

ested. The KALRO seed unit also markets seed of new KALRO maize hybrids *"until a hybrid is reasonable well known in its target area"*. However, this process creates problems for the above mentioned licensing process, and is thus part of the stakeholder discussions between KALRO and private sector maize seed companies.

The universities which have recently released sorghum varieties have initiated discussions on procedures for licensing their varieties to the private sector. They are also exploring a wider range of options for seed dissemination by working directly with large sorghum processing companies or grain traders with organized farmer groups, networks of farmer groups, supporting NGOs, and farmer seed cooperatives in the areas targeted for production. These linkages include production of certified early generation seed. Furthermore, options for collaboration with seed science departments within their university or 'business incubators' are being explored.

For a private company with its own breeding material and releasing its own varieties, the seed production from breeders' seed to certified seed for sale to farmers is a straightforward internal process, albeit accompanied by KEPHIS and its seed certification procedures. Early generation seeds tend to be grown by the seed companies themselves, or under close supervision (based on contracts).

SEED PRODUCTION AND CERTIFICATION

In Kenya, seed production is done (1) by farmers, mainly for their own use, in farmer-managed systems, and (2) on a commercial basis involving registration and certification by KEPHIS through the entire process. Most of the interviewed sorghum and maize farmers produce either some or all of their seed for the following season's use. Sorghum farmers tend to pay attention to varietal purity and select desirable panicles prior to the general harvest and store them or the threshed seed under special conditions to protect seed viability. Maize cobs are usually selected for seed after harvest, with several farmers saying that they used seed only from the middle of the cob and culled grains with off-type colors. Several farmers mentioned that specific hybrids *"tolerated"* recycling, and that their seed could be re-sown.

Producers of certified seed, such as farmers contracted by a seed company, need to be registered by KEPHIS. They have to complete an application procedure for every seed production field every season/year, and the source of the seed produced needs to be known and fulfill the necessary requirements for certified seed production. A KEPHIS inspector needs to visit each seed production field at least twice during the season, and needs to give an authorization for transporting the estimated quantity of seed to the seed processing plant, where it can then be inspected for seed quality. In most cases, the seed company that is contracting the seed grower is paying these travel costs in addition to the certification fees. These fees are charged according to rates published in the

Kenya Gazette, an official government journal. The travel costs from the nearest KEPHIS office need to be paid extra and can be substantial as there are only seven regional offices in Kenya.

The national seed trade association STAK is negotiating with KEPHIS to reduce certification costs by allowing STAK or individual private seed companies to hire and train certification agents in collaboration with KEPHIS. This would allow auto-certification of their seed production fields, but with close supervision by KEPHIS during the initial years and continued seed testing by KEPHIS laboratories.

The production of certified seed for maize is mostly managed by private companies or by KALRO's seed unit. Some companies produce the seed on their own land, or with groups of small-scale farmers in the vicinity. Others have individuals or groups of seed growers who produce on contract. Groups of farmers collectively contracted by companies such as Kenya Seed Company, Seed Co Ltd. produce maize hybrids or sorghum varieties such as 'Seredo', 'Serena', 'Sila'.

Trans Nzoia County, where many seed companies are based, has large-scale farmers, sometimes in organized groups, produce hybrid maize seed on contract. The contracts may differ as to whether the company provides farmers with inputs for cultivation on a credit basis, who pays the certification fees, and what prices are paid for harvested seed. The company takes responsibility for the storage, conditioning and packaging of seed.

Tharaka Nithi County produces certified sorghum seed in clusters of larger-scale contract farmers for the KALRO Seed Unit, with similar types of arrangements. In Homabay County, groups and associations or cooperatives of small-scale farmers also produce certified seed, mostly of sorghum, on contract for private companies, or in some cases for direct sale to farmers and other buyers, including NGOs. Seed produced for direct local sales is usually conditioned by the individual farmers and packaged locally, thus creating local employment. All production and conditioning steps are monitored by KEPHIS, which provides a notification once a seed lot is certified.

Although the contract growers usually have no choice of the variety to produce and only few options on agronomic practices (when to sow, weed, spray, rogue off-types or harvest), the advantages stated were having a guaranteed market for their harvest and a higher price compared to that of grain, thus facilitating access to quality inputs and financing. However, the seed producers are usually paid only after their seed lot is certified, with payments often received late.

Farmer seed producers receive training on technical issues and suggested that seed companies could offer more training opportunities, e.g. on aspects such as fertilizer use and crop management, and be more consistent with issuance of production contracts to enable farmers to properly plan their collective production schedules. Sorghum seed producers were interested in links with other value addition platforms and felt a need for research on techniques for controlling bird damage in sorghum.

Seed companies indicated that producing more seed of preferred hybrids would enhance their profitability. However, production capacities are limited; interview partners mentioned reduced farm sizes (due to inheritance laws), making isolation more difficult, and limited irrigation facilities as hindering factors.

SEED PROCESSING

When it comes to processing the certified seed, private seed trade companies generally have one hub to which all seed is transported for processing; cleaning, sorting/grading, treating with chemicals against common seedling diseases, and packaging for sale. After cleaning and sorting/grading, KEPHIS needs to sample each seed lot to ensure that the minimum criteria for the specified seed class are met. Certified lots of seed are stored under appropriate conditions, and only when the time for sale approaches are they treated and packaged for marketing. Certified seed in Kenya is always packaged and treated with specific chemicals for seedling and seed borne disease control. One group of sorghum farmers in Tharaka Nithi indicated regular dissatisfaction with the seed

treatment on certified sorghum; they regularly purchased a more effective product with a systemic fungicide to “re-treat” the seed themselves.

STAK, with the Kenya Market Trust, commissioned a study on impact of these taxes and levies (locally called ‘cess’) on seed businesses and options to reduce them.

The levies and road taxes charged by county governments on transported agricultural goods were indicated to be a factor that raised costs for companies with a centralized seed-processing hub and longer transportation routes.

Different companies use different types of materials for packaging, paper or plastic, printed with their logos, variety names, and some information about the variety. The smallest packet size for maize and sorghum is 2 kg. One company reported providing 1 kg packages only for special orders such as from NGOs for large distributions. Smallholder farmers in all three study regions voiced preference for smaller packet sizes, so that they can buy the quantity they actually need, or the quantity they can afford. Seed sellers in Homabay County also wanted smaller packets, so that they can attract more customers and increase total sales.

Different companies use different types of materials for packaging, paper or plastic, printed

Members of a farmer seed cooperative in Homabay County who market seed directly to other farmers reported processing seed manually using traditional techniques for local sale. This processing, done by members of the cooperative, provided additional income for those members.

Farmers who produce their own seed did not report any specific procedures for seed processing except threshing just before sowing time. None of the farmers in Trans Nzoia or Homabay who were using their own farm-saved or grain market seed spoke about using chemical seed treatments.

SEED QUALITY CONCERNS

Farmers mentioned two major types of seed quality concerns, varietal identity/purity and seed viability, e.g. germination capacity and vigor). The regulation standards for certified seed address both issues for both crops.

“I have experienced that problem many times. It could be that I get two packages and one germinates and the other doesn’t.”

A farmer in Tharaka Nithi

“My sisters’ package had no germination, causing her to resow, and with late sowing the crop could not yield well.”

A woman farmer

All interviewed farmers were asked whether they had experienced problems with seed quality for maize or sorghum in recent years. Most farmers who had purchased seed had experienced seed that germinated poorly or was not true to type for the variety they purchased. Farmers who received free seed through direct seed distributions reported extensive problems with poor seed germination.

Farmers who sowed seed that was not true to type or heterogeneous reported yields to be lower than expected. Farmers whose certified

seed did not germinate usually resowed their fields with farm-saved seed, either of a local variety, or a ‘recycled’ hybrid²². Several farmers reported that they use recycled maize hybrid seed under certain conditions. They knew which hybrids had less yield loss when recycling seed once. Farmers were aware of disadvantages of recycling seed but seemed to weigh those against risks of growing other available hybrids. Some farmers also reported

²² A ‘recycled’ hybrid means that harvested grain of a F1-hybrid is used for sowing, resulting in non-uniform ‘mixed’ populations, since F1-hybrids are not stable.

that their own farm-saved seed or grain purchased for sowing sometimes did not germinate, apparently most frequently following droughts that reduced the local grain and seed stocks.

Experiences with ‘fake seed’ (seed sold in packets looking like the original company packages but with other grain inside), were known in all three counties and spurred much discussions. The consequences of fake seed were apparently smaller harvests if they sowed this seed or the cost incurred to repurchase seed and the delay in sowing. Seed sellers suffered from poor quality seed as farmers blame them for the poor quality and loose trust. Seed companies mentioned that fake seed is a general issue that affects confidence in certified seed, with one indicating the appropriate management of packaging materials to be important for preventing diversion and misuse.

The problem of fake seed and its widespread nature was apparently linked to seed production failures during recent years, primarily triggered by crop losses due to the MLN disease. It was also seen as a general indicator that seed production was insufficient of specific highly preferred varieties for which there was unmet demand. KEPHIS, in collaboration with seed companies and seed sellers, has developed measures to reduce ‘fake seed’ that are entering implementation. These include: (1) certification of seed sellers, and informing farmers about these certificates, that can help farmers to identify truthful seed sellers; (2) advising farmers never to buy seed in packets that are damaged or already opened; and (3) providing seed packaging companies with scratch type labels with which farmers can call in a code and receive precise information about the seed lot, including date of production and if it was correctly certified, before sowing the seed.

Unsold stocks of seed remain with the buyer, be it the small-scale seed seller or the large-scale distributor, as all seed sales were “final”. Selling seed on commission was rare. Unsold seed, at this stage, being packaged and treated, can no longer be sold as grain. Although there was strong interest to return unsold seed, seed companies indicated that it was not possible for them to collect unsold stocks from the large number of distributors; hence, the seed sellers or distributors try to sell these old stocks the following season to avoid losses. During storage, the quality of seed can deteriorate for a variety of reasons. Regulations for appropriate seed storage facilities and KEPHIS inspection of seed sellers’ and distributors’ facilities exist, and KEPHIS reports on re-sampled seed that is tested after expiry of the original certification. A suggestion made for improvement was to ensure that farmers know where to find the year of seed production on the packet before deciding whether to buy it. Furthermore, farmers were interested in conducting simple germination tests before sowing the seed. Networking among distributors, and seed sellers, could help share information on where which seed is available for potential sale elsewhere.

4.2.4 ACTOR PERSPECTIVES ON SEED DISSEMINATION (KENYA)

Seed dissemination as a seed system function entails the flow of seed, money and information from seed producers to farmers. Here, our interview partners shared insights on seed distribution channels, information flow, financial management issues, as well as on seed prices, costs and risks.

SEED DISTRIBUTION CHANNELS

Seed distribution pathways in Kenya are diverse and differ for different crops and varieties. Major channels by which seed of new maize and sorghum varieties reaches farmers were identified based on interviews with farmers, seed sellers, large-scale distributors, seed companies, NGO development workers, and grain traders.

The most commonly discussed, characterized and analyzed pathway is the one the state corporation KSC started early on and is used now by many private seed companies. In this model, the company sells seed to distributors (often called agrodealers, or agrodealer hub), who then sell smaller lots of seed to seed sellers, often called stockists, agrovets or also small agrodealers. The final step is the farmers’ purchase from the seed sellers in their area. These seed sellers often market veterinary products, as well as feed concentrates, fertilizers, and pesticides.

Results (Kenya)

This model is strongest in areas where maize is widely grown and intensified production practices are common, as in Trans Nzoia County. The agrodealers of Trans Nzoia have started to organize themselves into an association for better communication and coordination to facilitate joint bulk purchases of seed from companies and to channel common grievances to the county government. Private seed companies may also have their own shops in certain larger towns, mostly near their headquarters.

Another type of retail outlets for seed is managed by the Kenya Farmers' Association (KFA). This association used to function as a parastatal, selling on priority to members, often with input credits supported by the national agricultural bank, the Agricultural Finance Corporation (AFC). KFA, presently undergoing privatization, is the major outlet for a new seed company evolving from a unit of the Agricultural Development Corporation (ADC), which is another parastatal. ADC functions as several distinct units that form a diversified, very largescale, agricultural producer. Earlier ADC produced seed for Kenya Seed Company, but four years ago started their own seed business with two hybrids from KALRO. One prime customer for ADC seed are their own grain production units, which cited KFA as their major seed distributor. KFA does market seed from a wide range of seed companies. It appears to have the trust and confidence of farmers and some stockists in rural areas although it does not have many retail outlets.

Some of the interviewed seed sellers reported marketing seed from a single seed company, mostly KSC, with some advantage offered for not selling seed from other companies. The sale of other merchandise, especially veterinary products, appeared to be of higher priority for many shops. Seed sellers regularly mentioned that they could not always get seed, or enough seed of specific farmer preferred hybrids, from their distributors, or the distributors from the seed companies. They attributed this, in some instances, to production failures for specific hybrids in specific years (e.g. due to the MLN disease), but also to over-production of other hybrids for which the companies were interested to liquidate existing stocks before selling new stock of the preferred hybrid or variety.

Farmers in Trans Nzoia and Homabay Counties frequently mentioned inability to purchase their preferred hybrid or, in areas with few seed sellers, delays of two weeks before stock of a specific hybrid is replenished. Farmers reported that under these conditions they bought a less preferred hybrid or recycling seed of their preferred hybrid, with reductions in quality and or yield expected. Farmers interviewed in Tharaka Nithi purchased seed far less often than in Trans Nzoia or Homabay and the issue of access to preferred varieties was rarely raised. The concept of newer and improved maize or sorghum varieties coming on the market appeared to be basically lacking in Tharaka Nithi County, both for seed sellers and for farmers. Although access to preferred varieties was commonly discussed in Homabay and Trans Nzoia, the mention of actual turnover of newer varieties replacing older varieties and anticipation of newer, improved varieties was at most limited, and did not reflect the fact that a large number of new varieties were released over the past ten years. The most recently released hybrids mentioned by farmers were from 2004.

Some other channels for supply of certified maize or sorghum seed were revealed through the interviews. Large-scale grain traders, e.g. selling to brewing companies, arranged seed supply to farmers so as to obtain the grain quantity and/or quality they desire. One farmer seed-producer association in Homabay also sold seed directly to farmers in the vicinity.

Farm Input Promotions (FIPS) Africa²³, a not-for-profit company incorporated in Kenya, is organizing village networks for seed sales to build demand for seed of specific new hybrids or varieties in areas where seed sales and seed seller networks are less developed. FIPS trains village-level communicators ('village advisors'), often young farmers recognized for their social skills, on variety choice issues, as well as principles of good agronomic practice. These communicators get a small commission on each sale, possibly becoming successful intermediaries between farmers and distributors or seed sellers over time. This activity, however, was seen to be competing with

²³ <http://fipsafrica.org/about-us/> (29 April 2017)

other seed sellers, with one owner of a small agrovet shop interviewed in a sorghum producing area not happy with this development.

“We get information from the Chief whenever there is a seed supply. We are never told about traits but that the seed is available, if you are interested to go to the Chiefs’ Camp and get your share.”

A Farmer from Tharaka Nithi County

In addition to commercial distribution channels of certified maize and sorghum seed, free seed distribution, particularly to farmers in more drought prone areas, is very common. Justifications of these distributions included it being a response to widespread crop failure during the previous season(s) and assisting vulnerable farmers in obtaining the needed agricultural inputs. Free seed distribution is also justified as a

tool to rapidly disseminate samples of newly released varieties to farmers in order to increase familiarity and adoption.

Free seed distribution occurred every year since 2011, and possibly earlier as well, in two Homabay and Tharaka Nithi — hence in two of the three counties selected for this study. Most organizations use the DSD approach (described in 4.1.4), whereby the distributing agency delivers seed to the local extension office, the local paramount chiefs or other local authorities, to distribute to the targeted beneficiaries.

A somewhat different approach is now being taken by the Kenya Cereal Enhancement Programme (KCEP), a government program for enhancing cereal production. Identified beneficiary farmers receive seed and fertilizer for one acre at 10% of the cost in the first year, and higher rates in the following years. Farmers need to cover transport costs for the inputs and their share of the purchase price. The farmers obtain the inputs from a single distributor or seed seller who has the contract for providing inputs to a specific set of farmers. In this case, farmers do have some choice of which crop or variety to purchase, depending on availability of seed.

Farmers also use their own ‘recycled’ seed of local as well as new varieties, especially for sorghum and for some of the older maize OPVs and specific hybrids, particularly if desired varieties are not timely available in seed outlets. Farmers in more risk-prone areas had knowledge of the specific risks associated with recycling seed, but accepted it in some cases to save expenses.

Local grain markets represent another source of seed for specific varieties of maize and sorghum, especially when farmers lost their seed stocks and/or did not have money for purchasing certified seed (see also Section 4.1.4). Certain farmers reported sometimes obtaining improved varieties or newly introduced local varieties as well as the commonly grown local varieties from small-scale grain traders. This was mentioned especially in areas that have only few seed sellers or distributors. Farmers' grain purchased from local markets could be of specific varieties expected to be well adapted to the locality, if sourced from specific trusted grain traders who usually know the origin of their grain. In Homabay County, one large grain trader (working with the brewery) provided farmers with seed of the desired variety, to ensure that he got good quality grain to purchase.

INFORMATION FLOW

Farmers in both Trans Nzoia and Homabay Counties mentioned getting information about new varieties from several sources such as demonstration plots, field days, and seed sellers. This was also the case in Tharaka Nithi County, although to a somewhat lower extent, particularly in the drier lower-elevation areas where the concept of new varieties was rare. Despite having several channels of information about new varieties, farmer’s comments indicate widespread desire and need for more relevant varietal information.

Farmers frequently mentioned ‘seeing varieties’ as an important way of learning about them — either by growing out free seed samples in their own fields for observation, or by seeing other farmers’ fields. Some farmers, however, said that they had received too many different seed samples, and could not remember which variety was sown where.

Demonstration plots and field days are organized by different actors; the extension service as part of development project activities, NGOs, seed companies and some seed sellers. A development agent told of working with seed sellers for effective managing demonstration field visits, advising that they be conducted by a respected farmer, held early morning or evening, focus on a single issue/message, and be repeated every two to three years in the same village. He also recommended conducting them before maturity while the plants are green and vigorous; a practice, however, that makes it difficult for farmers to observe problems at maturity such as grain mold, rotting or lodging.

Many farmers suggested having demonstration plots closer to them so that they could regularly observe the different varieties at different growing stages (see box). However, none of our interview partners presented results from such demonstration plots, or mentioned use of performance results from any source in informational programs with farmers. No one showed us any data on the superiority of new maize or sorghum varieties for yield or quality. Especially smallholder and women farmers reported that they had never been invited to participate in visits to demonstration plots, or that the plots were too far away to attend or to know if the varieties’ performance would be similar on their own farm.

Farmer-managed trials for variety comparisons and choice of varieties for seed production were described by one NGO extension agent. Farmer evaluation of these trials and inclusion of local control varieties for comparison were mentioned. This was the only case in all our interviews of efforts to collect comparative variety performance information with the intention of eventually enabling farmers to access information to compare adaptation and quality of new and old sorghum varieties, and to query their relative advantages in specific agroecological conditions.

Some farmers mentioned attending agricultural shows organized by the extension service, or seminars and training programs although many farmers indicated that extension services had weakened in recent years and/or hardly provided any information in their area. Responding to farmers eagerness to learn about new agricultural production techniques, especially new varieties and hybrids, KEPHIS, in collaboration with seed companies, has created a cellphone-based information tool called ‘Mbegu’ for communicating information on the adaption of hybrids for specific areas. However, no farmer we interviewed had so far experienced this.

Farmers sometimes mentioned receiving information from seed sellers. However, an inexperienced relative or employee is often in charge at the counter and is unable to provide information, even if the shop owner is experienced or does have information. Printed leaflets and information written on seed packages were hardly mentioned by farmers as useful sources of information. For some farmers, “word of mouth” from people they knew was the most convincing source of information regarding new varieties. One exceptional engaged and respected seed seller in Tharaka Nithi was reported to visit various women’s and men’s farmer groups, including church and savings groups, to tell about new varieties.

Some seed sellers indicated that they get little variety-related informational material to share with current or potential customers, and thus cannot give much advice to farmers. They did have the information provided on the seed packages, but some said they would like to have more information from seed companies. Some seed sellers who were also farmers grew the varieties themselves or sowed them as demonstration plots to have direct experience for themselves as well as for others.

Seed companies were said to contribute to agricultural shows with distribution of seed samples and brochures, as well as installation of demonstration plots. Demonstration plots however were considered too costly for seed

“Awareness creation, informing farmers is a big lack: nobody takes it as their responsibility. It does not only concern varieties, but also information about agronomy... grain storage is also a major problem.”

A national coordinator for seed activities

companies to do on a large scale. At least one company collaborated with an NGO that organizes village networks for farmer awareness (with mini-samples) and seed purchase of new varieties.

Information that seed companies obtain regarding performance of varieties comes from research, primarily from public breeders, or in-house breeding for some. Farmers in Tharaka Nithi County suggested having seed company representatives near to them to gain infor-

mation about varieties and as a channel for registering dissatisfaction.

Plant breeders obtain information about performance of their breeding materials and experimental varieties mostly through their own testing at experimental stations and through the results of NPTs. The KALRO breeders we interviewed did not mention any efforts to include farmer participation or input into varietal pre-release testing to aid the breeders’ decision making, or to develop information materials on performance of released varieties for informing farmers. There was no mention of clear channels by which breeders could obtain feedback on the performance, including the relative advantages and disadvantages experienced by farmers, of newer released varieties and hybrids. CIMMYT produces annual reports of their regional trials, although analysis of their on-farm trial results in Kenya were not available.

Extension service agents interviewed in Tharaka Nithi County reported conducting demonstrations and informational activities on behalf of projects with the corresponding project providing the information, but no activities on their own for obtaining or sharing varietal information. Large NGOs, even those involved in creating demand for seed and input financing options, indicated that no comparative results on varietal performance or profitability were available to share.

To summarize, despite the existence of many information channels, individuals of different actor groups indicated that they did not have sufficient information about new varieties. We did not find or hear of comparative, qualitative or quantitative data on performance of new versus control varieties that was accessible to farmers or the general public. We did meet some exceptional individuals, however, who were committed to sharing varietal information.

FINANCIAL MANAGEMENT

Limited cash availability at the time of sowing was repeatedly reported to limit farmers’ purchase of seed. Certain NGOs reported engagement in providing seed and other inputs to farmers on credit. Some large-scale traders described their strategies for providing input credit to farmers as a way of increasing the volume and quality of grain available for marketing. The terms of credit repayment were stipulated in contracts either on an individual or group basis.

Seed producers indicated difficulties caused by delayed payment by companies for their seed, with delays in obtaining certification being an important factor. Small-scale seed sellers reported how their limited capital hindered them from maintaining larger and more diverse stock of seeds. These seed sellers, as well as seed companies, wanted financial institutions to better understand the dynamics of seed businesses and provision of credit on more favorable terms. In contrast, other seed companies indicated that their marketing diverse varieties, and

especially across many diverse agroecologies, was a strategy for achieving more sustained seed sales and reducing cash flow problems. These companies reported being able to keep full-time marketing staff with benefits of maintaining trust and reliable relationships with distributors.

SEED PRICES, COSTS AND RISK

Farmers in more stress prone areas preferred to limit their expense on purchased seed in face of frequent crop losses, particularly for maize. A program for seed insurance was encountered, but only the cost of the seed was covered, with no coverage for other expenses, or opportunity costs. Women mentioned lack of financing as limiting access to certified seed more often than men.

The seed-to-grain price ratio for maize was stated by interview partners to be approximately 7:1 and for sorghum to be in the order of 8:1 at the time the interviews were conducted. The prices for maize hybrid seed that we noted were in the range of 185-260 Kenyan Shillings (KES) per kg, equivalent to 1,75-2,50 US-\$ (Table 6). KSC seed was usually sold at the lower prices mentioned, while international private companies charged the higher prices. However, grain prices can fluctuate very widely within and among years, and thus seed-to-grain price ratios had actually reached 2:1 for maize and almost 1:1 for sorghum in October 2017. The seed prices in Kenya seem to be little influenced by the actual grain prices at the times of selling the seed.

Differential price of seed seemed to play some role in seed choice, with KSC seed preferred by some farmers because of their lower prices, but also because of the trust they had in company. However, farmers’ decisions whether to buy seed seemed to be more dependent on other issues than seed cost *per se*, including (a) having the cash on hand, or other financing options; (b) the varietal characteristics, particularly adaptation and quality; and (c) the effort required to access the seed, e.g. distance to selling points.

Table 6: Grain and seed prices stated in interviews and seed-to-grain-price ratios for maize hybrids and sorghum OPVs in Kenya in February 2017

	Maize	Sorghum
Type of variety	Hybrid	OPV
Average grain price (KES/kg)	30	20
Average price of certified Seed (KES/kg)	225	160
Seed-to-grain price ratio	7:1	8:1

Seed producers having contracts with seed companies for hybrid maize appreciated the guaranteed (fixed) price — usually around double or triple grain price. Seed companies and seed sellers, however, indicated concerns over the volume of seed stocks and the cost of storage. Seed companies reportedly differ in their pricing and margins for distributors and seed sellers, payment schedules, as well as other undefined ‘incentives’ to promote sale of their seed.

4.2.5 ACTOR PERSPECTIVES ON SEED SYSTEMS IN RELATION TO CROP PRODUCTION AND USE (KENYA)

The seed system function ‘crop production and use’ is a major factor shaping demand for seed of certain varieties or quality. Adaptation and risk, aspects that are important for on-farm processing and use, as well as market demand were mentioned by interview partners as important issues for crop production and use, and are thus presented in this section.

ADAPTATION AND RISK

In **Trans Nzoia County**, all of the farmers interviewed grew hybrid maize. Small-scale farmers, and especially women, cultivated a small part of their fields with earlier maturing yellow-grained landrace varieties or “500 Series”-hybrids that are early maturing. This maize provides earlier harvests and enables farmers to cultivate a second crop, typically beans. Large-scale farmers, in contrast, cultivated only full-season hybrids (referred to as “600 Series”) bred for the highlands environments with their single and long rainy season. Farmers provided

The popular maize hybrid H614 was originally developed from two open pollinating varieties, one of which was selected from local Kenyan germplasm, the other one from a landrace germplasm originating from Ecuador. Hence, the grain quality traits of local Kenyan varieties were partly included in H614 and its successors, making these hybrids particularly popular in Kenya (Smale and Olwande, 2014).

detailed descriptions of varieties they used, including perceived advantages and disadvantages. Altogether, they described eleven hybrids and three landraces.

All farmers compared the newer hybrids to the first hybrid developed in Kenya for the highlands, H614D. Many farmers reported still growing H614D, particularly appreciating its adaptation to local conditions and its harder grains that resist mold and insect damage and are preferred for preparing the local dish *ugali*²⁴ or for roasting. Many other farmers have abandoned it

nowadays for higher yielding new hybrids. The biggest problem associated with many of the newer hybrids appeared to be their susceptibility to ear rot in the field before harvest. Upright ears and husks not totally covering the ear, exposing the developing grain to rain, contributed to ear rotting. Furthermore, the softer grains and lower test weights (weight per volume) were reported by farmers to contribute to susceptibility to grain weevil damage during storage, to ear rot as well as to lower flour yield per volume of grain. Other traits farmers suggested for improvement included improved resistance to lodging and diseases, including MLN disease, better nutrient efficiency, particularly adaptation to low nitrogen levels in the soil. One person further mentioned adaptation to soil acidity.

The most recently released hybrids mentioned to us by farmers were from 2004 and the most recent mentioned by seed companies were from 2008. Some of the newer released maize hybrids are indicated to have hard grain, but comparative data with H614D is not available.

Very few farmers in Trans Nzoia County mentioned growing sorghum. The sorghum that was cultivated was of a local variety adapted to ‘ratooning’. This sorghum was grown only for home consumption and on-farm use; it may be cut either for green fodder or for a first grain crop, and then regrown for grain. Cultivation of this variety covers the soils for a longer period, protecting it from erosion.

The two different agroecological zones in **Homabay County** define the production patterns and adaptation requirements, with maize and sorghum grown in both zones. The wetter zone, further away from Lake Victoria, has two reliable rainy seasons per year. Maize is more important in this zone, with both maize and sorghum often being intercropped with beans and other legumes. The drier zone, on the shore of Lake Victoria, has one main planting season per year (long rains, March to June), and only little rain from September to December. Sorghum performs better than maize in this area. However, in the second season birds can devastate the sorghum crop,

²⁴ *Ugali* is a common dish in Kenya, made from flour (usually maize) boiled in water or milk until it has a stiff and dough-like consistence.

Results (Kenya)

which is why maize, if any crop, is sown in that season despite its susceptibility to drought. A further problem is that the soils in Homabay are generally infested with *Striga*, a parasitic weed affecting both crops.

All farmers interviewed in Homabay County grew maize, but not all of them grew hybrids. Ten different hybrids as well as ten local maize varieties were grown by the 15 farmers interviewed. Short season maize hybrids adapted to both rainy seasons are grown. High yields, earliness and drought tolerance were the most frequently mentioned advantages of these hybrids. The most common disadvantages of available hybrids were reported to be ear rotting, poor grain storability and damage by weevils.

The farmers described the advantages of their local maize varieties in terms of traits related to yield stability and risk reduction, e.g. resistance to weevils, birds, rodents, or disease, as well as adaptation to specific agro-ecological conditions, e.g. waterlogged fields or very dry environments. The farmers' varietal descriptions also indicated that they target specific maize varieties to specific parts of their fields. Furthermore, the local maize varieties show a range of different grain colors — white, yellow and others, also targeting specific uses.

Sorghum is grown both as a cash crop and for home consumption. Farmers detailed a wide range of local varieties that are grown for different specific agroecological niches and uses. The local varieties differ for their earliness, which determines adaptation to specific growing conditions. Therefore, maturity along with bird resistance, *Striga* tolerance, and adaptation to acidic soils are traits that farmers are considering when choosing varieties, with farmers generally looking for varieties combining higher productivity with reduced risk of crop loss.

In general, women in Homabay County mentioned environmental adaptation more frequently than men as a necessary requirement guiding their varietal choice for both crops.

In **Tharaka Nithi County**, interviews were conducted in seven locations covering an altitude range from 532 to 890 m a.s.l. Sorghum was cultivated by all farmers across the entire altitude range, whereas maize was generally cultivated by farmers above 700 m. The number of varieties reported under cultivation was very small for both sorghum (basically 3 varieties) and maize (6). Risk of crop failure due to drought was very high, particularly at elevations below 700 m a.s.l. Sorghum was cultivated both for consumption and for the market whereas maize, when it was cultivated, was only for consumption.

The majority of farmers reported cultivating only three sorghum varieties, one improved variety ('Gadam', white grain), and two local varieties ('Kaguru', red grain and 'Mugeta', white grain). Two additional improved sorghum varieties were mentioned: 'M'tama 1', which one farmers had cultivated last year from a sample of seed given by the seed seller, and 'Silah'. Discussing with farmers about "*new varieties*" was often not straight forward as the variety options and the number of 'new' varieties was more a hypothetical idea than a concrete reality. A handful of other local varieties were mentioned in only one interview with members of a farmer association involved in preservation of local varieties. The sorghum traits that farmers most valued, based on their descriptions of varietal advantages and disadvantages, included market price, drought tolerance, quality for food, and yield in poor soil conditions.

The maize varieties that farmers reported growing were all early maturing; hybrids, e.g. 'Duma 43', 'DK8031' and 'Pannar hybrids', as well as the open-pollinating varieties 'Katumani' and 'KDV1'. The distinction between hybrids and open-pollinating varieties was not clear for many farmers and some seed sellers interviewed, with all being "*hybrids*". The desirable traits mentioned were first and foremost "*how much rain it needs*", followed by taste, size of grain or test weight.

ON-FARM PROCESSING AND USE

Maize was used for home consumption in all three study areas — to eat maize is now "*to be Kenyan*". Maize for home consumption was the norm also for farmers in Tharaka Nithi County, who either attempt cultivating maize despite chances of total losses, or for those who cannot even attempt growing maize, report selling sorghum grain to buy maize.

Farmers in Trans Nzoia County particularly appreciate the grain qualities of the hybrid H614D, e.g. test weight, grain hardness, storability of the grain and taste for principal dishes. This old maize hybrid is still grown, particularly by smallholder farmers, due to its preference for home consumption and better storability compared to some new hybrids. Early-maturing maize is sown on smaller parts of fields to provide food in the 'hungry period', before the main harvest. In Homabay County, farmers consume both improved and local maize varieties. Local varieties were appreciated for less weevil damage, better taste, the possibility to mix maize with sorghum, and high flour quality, whereas among the hybrids only two were mentioned to have good taste. Traits mentioned by the few maize growers from Tharaka Nithi County included taste of flour, taste when roasted, and early maturity for the hunger period as important quality criteria of maize.

Sorghum in Tharaka Nithi County is consumed primarily as porridge, using both the red grained ('Kaguru') and white grained ('Mugetha') local varieties as well as the commercially available variety 'Gadam'. A principal quality difference was that the red grained variety ferments more slowly than the white grained one, which helps porridge keep better but is less desirable for beer. Sorghum can be, and was, consumed in many other forms but they are rarer now as they are associated with poverty or famine and carry social stigma for some people. Food preparation from sorghum in Homabay is only done with the red grained types. Local sorghum varieties were identified with good flour quality and food yield ("*getting more ugali*"), taste, and the possibility of mixing with cassava, and brewing.

Women mentioned producing for home consumption more frequently than men, or mentioned only producing for home consumption. The women interviewed mentioned a greater number of quality traits than men for both maize and sorghum varieties; they also described these traits in more detail, including qualities for preparation of specific dishes (e.g. "*mixes well with cassava*", or "*with small quantity of flour we can make more ugali*"). The desired quality traits mentioned by both women and men were nearly always associated with the local varieties they grew.

Women clearly grow a larger number of local than modern varieties for both maize and sorghum; based on our interviews, women grew on average two local varieties and one modern variety for both crops, whereas men cultivated more modern varieties or an equal number of local and modern varieties for both crops. Approximately half of the women interviewed reported growing only local varieties of maize, whereas all men interviewed grew modern maize varieties.

MARKET DEMAND

A major quality criterion for marketed maize grain in Trans Nzoia County is that it be "*clean grain, not rotten*". One medium-scale maize miller in Trans Nzoia analyzes grain for moisture content and aflatoxin contamination, rejecting approximately 30% of the lots delivered, with the carcinogenic aflatoxin being a major problem. Grain traders in the local market of Kitale visually assessed lots for moldy grain. Grain lots with more rotten grains were still marketed, apparently for distilling, which is illegal if done informally. Traders did not differentiate grain by its hardness (as did farmers), considering that all grains are attacked by weevils. They use chemical treatment, and triple bags for hermetic storage for their home use. Large or uniform grain size were also sometimes mentioned.

Maize grain in Homabay County is handled primarily by small-scale traders. Their quality requirements are based on consumers' preferences: clean grains, mostly white and medium to large sized grains, not damaged by weevils or absence of moldy grains. They also strived to assure that grain quality would at least avoid being condemned by public health ministry officials during market inspections.

The use of **sorghum** by the East African Breweries created a new market to which farmers in both Tharaka Nithi and Homabay Counties are responding. The large grain traders in Homabay apparently deal only with white sorghum and do not handle maize. The breweries demand white sorghum grain, and both the predominant released

variety 'Gadam' and the white local variety 'Mugetha' are sold to this market in Tharaka Nithi. Grain purchased for this purpose also has to be free of physical impurities and molds (or mycotoxins) and have acceptable moisture content. Certain large traders interviewed in Tharaka Nithi and Machakos Counties provide seed and inputs to farmers on credit, with reimbursement based on grain at harvest, to ensure that they get the varieties they need.

Sorghum food grain markets, handled by smaller grain traders, exist in both Homabay and Tharaka Nithi Counties. Farmers in Tharaka Nithi mentioned grain price as an important varietal characteristic, although the relative price for specific varieties apparently varies depending on supply and demand. One woman mentioned growing two local varieties and one improved variety, i.e. two white and one red variety, as it was unsure which of them would have the higher price in the market. Grain traders in Homabay preferred brown or red sorghum varieties.

4.3 WORKSHOP RESULTS: PRIORITY OPTIONS FOR SEED SYSTEM DEVELOPMENT IN KENYA

The 18 workshop participants (14 men and 4 women) represented all main actor groups (farmer*, breeder, seed company, seed seller, seed regulation/certification*, extension* and others such as the Seed Trade Association and NGOs). Although only four women participated, they represented diverse seed system roles (as indicated with '*'). Six study team members facilitated the workshop and documented the results.

The seed system issues identified for improvement by field interview participants in Trans Nzoia, Homabay and Tharaka Nithi counties (see section 4.2 above) were reported at the start of the workshop. These issues included suggested improvements for farmers' access to varietal information, seed supply, quality, marketing, access and regulation, as well as varietal choice and diversity.

4.3.1 WORKSHOP SESSION 1: PRIORITIES FOR SUSTAINABLE SEED SYSTEM DEVELOPMENT (BY COUNTY)

Actors, in individual county groups, discussed options for seed system improvement by considering the points suggested in the field interviews (field interview suggestions written on cards were provided by the study team to facilitate group discussions). The workshop participants reviewed and discussed the suggestions and in some cases modified them or added further cards. They finally presented their results to the plenary

The participants from **Trans Nzoia** County suggested actions for various actor groups. Important suggestions for government actors were that the role of government agencies or parastatal organizations in relation to the private sector should be clarified in order to avoid competition, and that more transparency was required regarding procedures and data generated by state agencies, e.g. data of national performance trials. The group suggested that alternative options to the current seed certification process, such as voluntary certification, 'truthfully labelled' or 'quality declared' seed, be explored to speed access to improved varieties. It was further suggested that plant breeders develop varieties with improved traits, e.g. for milling quality, pest and disease tolerance, nutrient use efficiency, as well as early maturity, grain weight and yield. Priorities identified for agrodealers were increasing the number of outlets to reach more farmers and offer more different varieties along with other inputs, e.g. fertilizers. Finally, farmers could support the seed system by buying seed and improving agronomic practices.

"Experience is more important than words. Therefore, farmers should have a chance to try out new varieties themselves."

A workshop participant

Participants from **Tharaka Nithi** County made a number of suggestions that went in the same direction. For example, they recommended that farmers should get free seed samples of new varieties for experimental purposes or that smaller package sizes should be offered, that agrodealers should engage more in demonstration

and communication activities, and that representatives of seed companies should be accessible to individual farmers, farmer groups and agrodealers. To improve availability of seed closer to farmers, they suggested that local groups should be trained for seed production and new groups be encouraged. Furthermore, seed could be sold directly to farmer groups at reduced prices, in order to improve access. The participants further made a number of suggestions relating to seed quality issues, e.g. that seed quality should be monitored after certification, that packaging should be improved with regard to materials used and labelling, and that unsold seed should be recalled by seed companies. A further set of suggestions was related to maintaining local varieties and improving farmers' skills for selection in these varieties, and seed production. Priorities identified for breeding were improved resistance of varieties to insect pests and development of varieties that are good for food and marketing purposes. Lastly, suggestions were made to enhance farmers' skills for grain marketing and pursuing alternative marketing pathways.

Participants from **Homabay** County suggested that the market for sorghum and sorghum products should be diversified, which may require increased efforts from research and extension to meet and enhance consumer demand for sorghum-based products. Further recommendations were related to free seed distribution, an instrument that should be better organized and targeted according to transparent criteria, and channeled through seed sellers. Communication and trust between seed producers and companies could be improved, e.g. with regard to weighing of the produce and price setting. Private seed certification agents who are based locally could help reduce certification costs. Moreover, the group suggested that seed distribution should be more decentralized to reduce travel and transport costs for farmers in remote areas. Also, extension agents and farmers could work jointly to improve farmers' skills in selecting varieties that are suitable to their conditions, in integrating other farming practices with variety choice, in developing farmer networks for more exchange of seed and seed- and varietal-information, and in maintaining, selecting and producing seed of local varieties. The problem of recurrent drought, also in connection with climate change, should be addressed more effectively by breeders.

"Farmers are rarely the focus of the chain, even though they should be the focus."

A workshop participant

"It is important to know that 'informal' seed is more than a fall back! Farmers should be in control of seed."

A workshop participant

This groups' last recommendation was that group-based seed and grain production could offer interesting opportunities for youth groups in rural areas.

Discussion In the plenary session highlighted that information for farmers did not just mean leaflets, but also possibilities to learn from their own experience. The content of available information should be improved in order to be more useful for farmers.

Issues with more contentious viewpoints included the existence of competition in the private sector, so that the need for parastatal seed companies, like KSC, was questioned. Such companies should not compete with the private sector, but rather take on a complementary role. The importance of offering smaller sized packages was acknowledged, even though questions remained open as to the additional costs. Likewise, the suggestion to return unsold seeds raised questions regarding the distribution of responsibilities and costs among actors.

Regarding seed of local varieties, participants stated that the government did not interfere with farmer-to-farmer seed distribution as long as the seed was not packaged. However, this form of seed production is not addressed at all in Kenyan seed legislation even though most of the sorghum and legume seeds are locally produced by farmers. Some participants indicated missing a stronger focus on farmer-managed seed system activities. Fur-

thermore, diverging views were expressed concerning the quality of newly breed varieties with regard to adaptation and grain quality traits. Farmers in particular were interested in getting more involvement in variety selection and seed production, while other participants preferred the current status.

4.3.2 WORKSHOP SESSION 2: PRIORITIES IDENTIFIED BY VARIOUS ACTOR GROUPS

For the second round of discussion, three major actor groups were formed: (1) Farmers; (2) plant breeders, seed companies and KEPHIS; and (3) extension agents, NGO representatives and agrodealers. The actions for these actor groups suggested in the first workshop session were taken as a starting point for discussions within each group. The task for each group was to prioritize actions that should be put into practice by the respective actor group. The three top priorities of each group are presented in Table 7. These priority actions reveal a strong interest in improving skills for information sharing and use at various levels.

4.3.3 WORKSHOP SESSION 3: PRIORITIZED OPTIONS FOR SUSTAINABLE SEED SYSTEM DEVELOPMENT IN KENYA AND SUMMARY

In the final plenary session, the three top priorities of each actor group, presented in Table 7, were listed and scored by all workshop participants, resulting in a ranked list of priority actions for sustainable seed system development in Kenya (Figure 8). Hence, most participants agreed that establishing county stakeholder forums on seed system issues, breeding varieties with special attributes as well as training and capacity building of farmers and agrodealers on variety and seed issues were top priority actions for enhancing seed system development.

Table 7: Priority actions for seed system improvement identified by workshop participants from three groups of seed system actors in Kenya.

	1st Priority	2nd Priority	3rd Priority
Group 1 (Farmers)	Enhance capacities for sharing information on variety and seed issues: E.g. organize farmer-exchange-visits in order to be better 'equipped' with information	Improve skills in variety testing and choosing the right varieties: E.g. farmer managed variety comparisons in their own fields to understand the behavior of a variety in a particular zone, or under specific growing conditions	Use IT-tools to exchange experiences with others about specific varieties and agronomic practices: To better plan activities, e.g. according to seasonal calendars, and exchange experiences with specific hybrids

(Table 7 continued)

	1st Priority	2nd Priority	3rd Priority
Group 2 (Breeders, seed companies and KEPHIS)	Breeding for specific traits and attributes: Most of the mentioned traits are already worked on, but reduced regulation	Improve public access to information: Needs some investment, training etc.; variety catalogue is already available, including SMS service for	Deliver quality seed to farmers more swiftly: Exploring options of 'open source' systems, voluntary certification or 'truthfully

	could help that new varieties can reach farmers faster	recommendations of varieties for specific areas (KEPHIS)	labelled' seed, including ex-ante impact analyses
Group 3 (extension agents, agrodealers and NGOs)	Organize county stakeholder forums on seed system issues	Conduct training of farmer groups and agrodealers on variety and seed issues	Improve information exchange among actors



Figure 8: Options for sustainable seed system development in Kenya in order of preference (from top to bottom), prioritized across all workshop participants; the last two options were scored equally.

5 RESULTS OF MALI CASE STUDY: ECONOMIC AND REGULATORY FRAMEWORK, ACTOR PERSPECTIVES AND PRIORITIES FOR SUSTAINABLE SEED SYSTEM DEVELOPMENT

Our Mali case study is structured according to the same three sections as the Kenya study; with an overview of relevant economic aspects and the regulatory framework, results from field interviews of seed system actors, and results of the stakeholder workshop.

5.1 ECONOMIC AND REGULATORY FRAMEWORK FOR SEED SYSTEM DEVELOPMENT IN MALI

This section provides basic economic information on Mali's agricultural, food and seed sectors, food and seed aid, and the regulatory framework for the seed system.

5.1.1 BASIC ECONOMIC INFORMATION ON MALI'S AGRICULTURAL AND FOOD SECTOR

Mali is the eighth-largest country in Africa with a population of 18 million people belonging to various Sub-Saharan and Saharan ethnic groups. Population growth continues to be high (around 3% p.a.), with increases of approximately one million people every two years²⁵.

Most of Mali's people live in the southern parts of the country; only 10% live in the three northern regions of Gao, Kidal and Timbuktu²⁶. *Per capita* GNI was 760 US-\$ in 2015 (Atlas method)²⁷; Mali's GNI *per capita* increased by about 149.5 percent between 1990 and 2015. Mali's HDI value of 0.442 in 2015 ranks it 175 out of 188 countries and territories for which the HDI is assessed (UNDP, 2016b). Mali is thus one of the world's 'least developed' countries according to official UN statistics (UNCDP, 2016). Mali's national statistics institute, INSAT, estimates that 47% of the population were poor in 2015, with the majority of this group living in rural areas, where more than half of the population is considered to be poor (Daou, 2016).

Agriculture is a cornerstone of Mali's economy, with 80% of the population being engaged in agricultural activities, including livestock and fisheries. In 2015, the agricultural sector accounted for 40% of the country's GDP²⁸, with dryland cereals, rice, livestock and cotton being the most important agricultural products. Raw cotton accounted for 20% of Mali's exports (by monetary value) in 2015, while oilseeds, tropical fruits, animals and livestock products together accounted for another 10%, approximately. Other important export goods are gold and mineral fertilizers²⁹.

Pearl millet and sorghum are the most important staple food crops in Mali, with approximately 1.76 million ha (pearl millet) and 1.26 million ha (sorghum) annually cultivated (average of years 2010-2014, FAOSTAT data). Annual production of pearl millet varies between 1.2 and 1.7 million t per year, and for sorghum between 0.8 and 1.2 million t per year, depending on agroclimatic conditions. Average yield levels are 0.86 t/ha for pearl millet and 0.93 t/ha for sorghum (average of years 2010-2014, FAOSTAT data).

Maize and rice are grown on less area (maize: 0.7 million ha; rice: 0.6 million ha, average of years 2010-2014, FAOSTAT data) but, given more favorable production environments³⁰, produce higher yields (2.3 t/ha for maize and 3.4t/ha for rice paddy (averaged over 2010-2014, FAOSTAT data). Therefore, the total grain production of rice (2.1 million t year⁻¹ and maize (1.5 million t year⁻¹ averaged 2010-2014, FAOSTAT data) exceeds the annual

²⁵ <http://www.worldometers.info/world-population/mali-population/> (25 April 2017)

²⁶ <http://www.worldbank.org/en/country/mali/overview> (25 April 2017)

²⁷ <http://data.worldbank.org/country/mali> (25 April 2017)

²⁸ <http://data.worldbank.org/indicator/NV.AGR.TOTL.ZS?locations=ML> (25 April 2017)

²⁹ <http://atlas.media.mit.edu/en/profile/country/mli/> (25 April 2017)

³⁰ See Section 3.2.5 (Choice of Study Areas) for more details on yield variation among sites.

pearl millet and sorghum grain productions in most years, particularly for rice. The rice production in Mali continues to increase in recent years; amounts produced in 2014-2016 are estimated to have reached around 2.3-2.7 million t³¹.

Mali is not entirely self-sufficient for staple food crops; import quantities of maize and rice exceeded export quantities on a regular basis between 2009 and 2013; while sorghum was imported only in two out of five years (2012 and 2013) and exported in one year (2012). Millet was not imported, but exported, though in small quantities (within a range of 71-322 t annually for the period 2009-2013, FAOSTAT data). However, wheat is imported on a regular basis, between 89,100 t/year and 227,447 t/year, for the above-mentioned five-year period (FAOSTAT data).

Maize, wheat and rice are thus the staple cereals that are imported to Mali on a regular basis (see Figure 9), with an upward trend, however, being observed only for wheat (considerably influenced by last two years of the period shown; wheat imports remained at a high level of around 280,000-325,000 t annually in 2014-17, according to USDA data³²), and large variation without upward trend for rice.

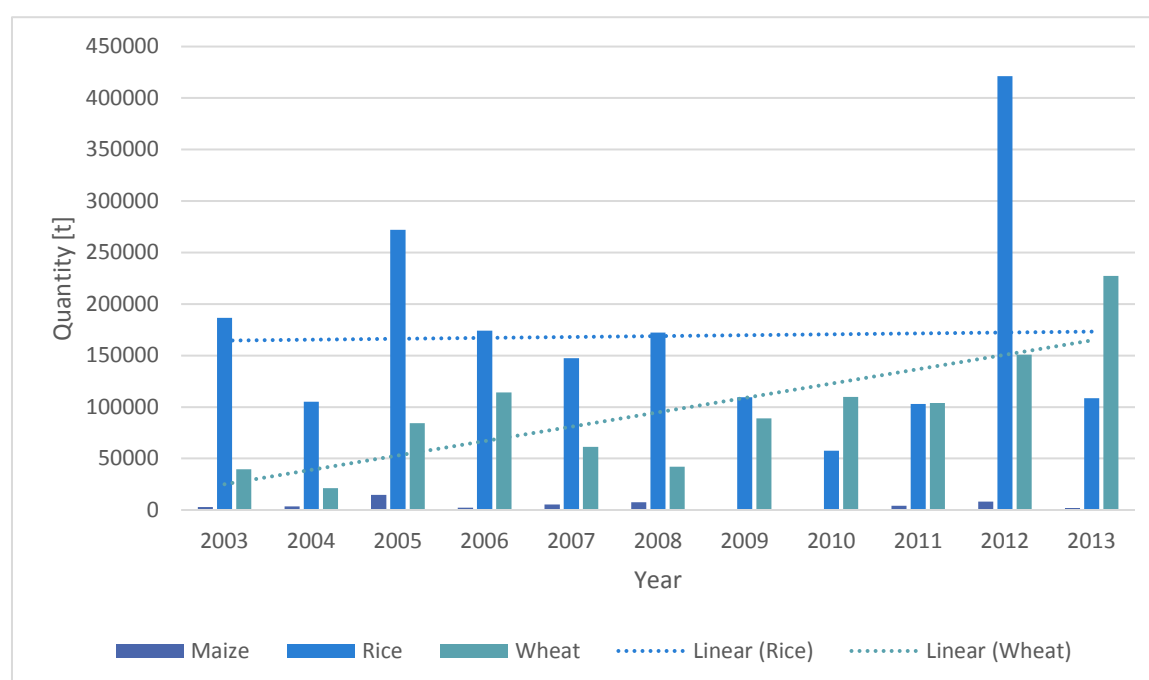


Figure 9: Quantities of grain imports (maize, rice, wheat) in Mali, 2003-2013 (FAOSTAT data).

In recent years, Mali has made progress in increasing its self-sufficiency for rice by increasing domestic production, partly due to an increase in the area cultivated with rice, along with favorable weather conditions. Thus, for 2016/17 and 2017/18, rice imports are expected to be around 50,000 t only. The goal is to attain self-sufficiency in rice by 2018 (USDA, 2017). Furthermore, several initiatives have been made to stimulate domestic wheat production as well³³, which is however not the focus of this study.

³¹ <http://oryza.com/tags/mali-rice-imports> (25 April 2017)

³² <http://www.indexmundi.com/Agriculture/?country=ml&commodity=wheat&graph=imports> (22 July 2017)

³³ E.g. via the SARD-SC wheat project, an initiative funded by the African Development Bank and implemented by the International Center for Agricultural Research in the Dry Areas (ICARDA) in cooperation with NARIs.

5.1.2 REGULATORY FRAMEWORK FOR SEED SYSTEM DEVELOPMENT (MALI)

Mali's regulatory framework for seed system development is briefly described in terms of its membership to regional organizations and international treaties, its national legal provisions, as well as policies and sector strategies.

MEMBERSHIP TO REGIONAL ORGANIZATIONS

Mali is a member of ECOWAS and of the African Intellectual Property Organization (*Organisation Africaine de la Propriété Intellectuelle, OAPI*). Hence, processes to revise and implement policies concerning variety protection and seed legislation in Mali are harmonized among the member states of both organizations.

MEMBERSHIP TO RELEVANT INTERNATIONAL TREATIES

Mali is a state party to the CBD, the ITPGRFA, the Cartagena Protocol on Biosafety and the Nagoya Protocol on Access and Benefit Sharing. Just like Kenya, it is also a state party to the ICESCR.

OAPI accessed UPOV as a regional organization in 2014 under the 1991 Act of the Convention and has started to operate a plant variety protection system that covers the territories of its 17 member states³⁴. ECOWAS has established a common seed legislation framework, which entered into force in 2010, and has since been implemented by its members; this process is ongoing, including in Mali (see below).

NATIONAL LEGAL PROVISIONS

The Seed and Plant Variety Act (*Loi 10-32 (2010) relative aux semences d'origine végétale*³⁵) provides the legal basis for the seed system in Mali. Varieties thus need to be registered in a national catalogue prior to starting seed distribution. A national committee has been created to work on the implementation of new rules, and responsibilities for variety registration as well as seed certification have been mandated to the national seed laboratory LABOSEM. Plant breeders' rights can be granted upon request, but there is presently no system for collecting royalty fees.

Traditional varieties are protected as a national heritage, but it is not very clearly specified in the law how this is to be implemented in practice. Farmers are allowed to resow farm-saved seed on their own farms, but distribution requires variety registration and certification of seeds, even though this legal requirement is presently not yet fully implemented.

Seed distribution, including seed import and export, are also regulated under the Seed and Plant Variety Act. These activities require a permission of the Ministry of Agriculture, and seed needs to meet phytosanitary standards that are, however, not specified further by the law. GMOs are currently not used in Mali; testing is so far only allowed in closed systems. Issues relating to GMOs are regulated under the Biosafety Act (*Loi n°08-042-AN-RM relative à la Sécurité en Biotechnologie (2008)*³⁶).

NATIONAL AGRICULTURAL POLICIES AND STRATEGIES

The government of Mali published a **development strategy for the agricultural sector** in 2013 (*Politique du Développement Agricole Du Mali*³⁷). Major objectives of this policy strategy include increased food security, poverty

³⁴ According to an UPOV press release, available at:

http://www.upov.int/edocs/pressdocs/en/upov_pr_097.pdf (19 December 2016)

³⁵ <https://mali.eregulations.org/media/DNA%20Loi%20n%2010-32.pdf> (19 December 2016)

³⁶ <http://faolex.fao.org/docs/pdf/mli152165.pdf> (18 December 2016)

³⁷ http://www.dngr.gouv.ml/pdf/Politique_D%C3%A9veloppement_Agricole_2013.pdf (17 December 2016)

reduction, and ‘modernization’ of the agricultural sector, as well as sustainable and rational use of natural resources. The role of the private sector is said to be a ‘motor’ for development; however, the roles of other actors, including public sector, NGOs and others, are also recognized; the multifunctional dimensions of family agriculture are reaffirmed. Consequently, the strategy aims at leveraging investment in rural areas, including in the development of improved farming technologies, e.g. mechanization and use of ‘improved’ seed, and in value chain development.

In addition, a **Seed Sector Policy** was published in 2009 (*Politique Semencière du Mali*³⁸), which emphasizes the importance of high quality seed for increasing the productivity of the agricultural sector. Specific objectives include improved training, planning, coordination and financing, strengthening of the regulatory framework, and facilitating commercialisation. The policy includes an action plan, which gives the Malian farmer seed-producer groups (*“paysans semenciers”*) an active role.

Furthermore, there are specific strategies targeting agricultural products; for cereals, for example, there is a **National Rice Strategy** (Ministère de l’Agriculture, 2009), highlighting the country’s potentials for rice production, the growing demand (at that time exceeding domestic production), and the relative superiority of rice for income generation, e.g. compared with sorghum or pearl millet. Further important agricultural programs include agricultural input subsidies for seed and fertilizer (see Section 5.1.4).

Mali has been supported in the implementation of the new legislation by the West Africa Seed Program (WASP), a five-year program (2012-2017) funded by the United States Agency for International Development (USAID) and regionally implemented by the West and Central Africa Council for Agricultural Research and Development (CORAF/ WECARD). Challenges still faced at the end of the funding period include access to funding for implementing the required activities, as well as developing business models that stimulate demand (Dagnoko, no year).

VARIETY RELEASE PROCEDURES

The procedure for variety registration in the National Catalogue of Mali are presented in a document entitled *“Manuel de procédures pour l’inscription des variétés au catalogue national des espèces et variétés”*. This manual is based on a manual elaborated by the Seed Science Center of the Iowa State University for variety registration, used for the West and Central Africa Council for Agricultural Research and Development (WECARD) regional catalogue of varieties; the Malian Catalogue is harmonized with the Regional Catalogue.

To register a variety, the breeder or owner of the variety is to make a request to the president of

the national seed committee (*Comité National des Semences d’Origine Végétal* (CNSOV)), who in turn is to refer it to the full CNSOV. The CNSOV should meet to define the conditions (the cost) and schedule the field visits to evaluate the variety over three years. Each field visit is to be reported. The CNSOV is to test the variety and the breeder to provide the seed. If the reports are deemed to be conclusive, the results are to be forwarded to the CNSOV president who is to decide on acceptance of the variety. The head of the National Seed Laboratory is then to revise the National Catalogue to include the new variety.

In practice however, the CNSOV (established in 2014) does not yet have an office nor resources for functioning. As such, it is the breeder who covers all costs and conducts the tests that are supposed to be conducted by CNSOV. Rather than the three reports that CNSOV is supposed to produce, a temporary commission refers to the

³⁸ http://www.fao.org/fileadmin/user_upload/spid/docs/Mali/Mali-Poilitique_semenci%C3%A8re_23_d%C3%A9cembre_09_vfrancaise.pdf (17 December 2016)

last three year reports of the breeder for deciding on the variety, and the head of the National Seed Laboratory has updated the National Catalogue once in 2016. So far, no official decree has been issued to regulate procedures for the nomination of members, their number, or the composition of the CNSOV. The same applies for the creation of the National Seed Laboratory.

Seed multiplication can begin once new varieties are registered in the National Catalogue. The seed multiplication steps include production of breeders' seed and foundation seed, usually by the breeder, followed by two generations of certified seed (R1 and R1). The certified seed is then disseminated by seed enterprises, agro-dealers, farmer cooperatives and individuals.

SEED CERTIFICATION

The procedure for seed certification are described in the same manual mentioned above and consists of the following steps:

- Registration of the seed producer.
- Notification by the seed producer before the 15th May to the commission indicating the producers' name, location, area of production, variety, category and origin of the variety, and the preceding crop.
- Field inspections (before flowering, during flowering, and after flowering).
- Sampling of seed after harvest.
- Laboratory analysis of the seed lot.
- Treatment of seed lots that are accepted.
- Labeling of accepted seed lots.

In practice however, the registration of seed producers and the treatment of accepted seed lots are not demanded. Also, the number of control visits often is less than three. The classes of seed in Mali are breeders' seed, foundation seed and certified seed, which can be certified as R1 and R2).

Only the official seed laboratory is authorized to certify seed in Mali. Currently there is only one laboratory in Bamako that analyses all samples for Mali. However, specifically trained agents in each district tend to have authority to conduct field inspections.

5.1.3 STRUCTURE AND ESTIMATED SIZE OF SEED MARKETS FOR IMPORTANT CEREAL CROPS (MALI)

The production areas for the four staple crops targeted in this study (presented in Section 5.1.1), along with recommended seed rates, are used here for calculating the estimated size of seed markets for sorghum, pearl millet, maize and rice in Mali (Table 8).

The seed rate for rice varies more than for other crops according to production conditions and farming practices, i.e. irrigated *versus* upland conditions, or transplanting of seedlings *versus* direct sowing. Transplanting appears to be more common in irrigated production systems in Mali than direct seeding, so that within the above-mentioned range, the lower seed requirements can be assumed for most rice production systems in Mali. To summarize, certified seed presently is estimated to account for approx. 5% of the seed sown for sorghum and pearl millet crops, and for approx. 10-15% of the seed sown for maize and rice crops. However, the share is higher in some 'high potential' production areas, and lower in drier areas of northern Mali. In a study conducted in Douentza district in 2006, for example, farmers relied on their own local varieties for all crops, except for rice (CRS/Mali and Partners, 2006).

Table 8: Cultivated area, recommended seed rates, estimated total amounts of seed required for sowing and amounts of certified seed available for sorghum, pearl millet, maize and rice crops in Mali.³⁹

Crop	Cultivated area [million ha]	Recommended seed rate [kg/ha]	Estimated total amount of seed required for sowing [t]	Amount of certified seed available [t]	% of total seed required
Sorghum	1.26	5-8	6,300 - 10,080	380.7	4-6
Pearl Millet	1.76	3-5	5,280 - 8,800	313.9	4-6
Maize	0.7	20-25	14,000 - 17,500	1,430.6	8-10
Rice	0.6	40-80	24,000 - 48,000	4,436.0	9-18

The national seed laboratory indicates that the amount of certified seed in the last 5-6 years, following implementation of the 2010 seed legislation, increased by more than 60% for rice and maize, and by more than 600 to 800% for sorghum and pearl millet⁴⁰. Hence, there is considerable dynamic in Mali's certified seed market for

staple cereals as well as for other crops such as sesame and cowpea, albeit at a lower level.

International NGOs provide considerable support to the Malian seed sector. Private seed companies received training and/or provision of startup capital, e.g. for obtaining seed conditioning and packaging facilities. Support to agrodealers located in more rural areas has included training on communication tools, demonstrations, business management, as well as equipment for their shops. Some support goes to farmer seed producers, and NGOs sometimes act as entities soliciting certification of specific seed lots produced by farmers.

For the entire Malian seed sector, including all crops, it is estimated that around 80% of seed used by farmers in Mali is from traditional farmer-managed or community based systems. Furthermore, it is typical for Mali's seed sector that diverse combinations of actors are involved in breeding, production and marketing of certified seed in Mali (Diallo and de Boef, 2012). For example, a great number of farmer groups and cooperatives, in partnership with breeders, engage in variety testing and the production and marketing of certified seed, including direct seed sales to other farmers.

Agrodealers and emerging private seed companies mostly market seed they obtain from farmer cooperatives or groups after certification, generally without prior contracts. NGOs and government institutions purchase certified seed from cooperatives or seed companies for distribution to their target groups, either free or at reduced price (see Section 5.1.4). Some individual grain traders, particularly of rice but also of other cereals, and more rarely grain processors, buy larger seed volumes from a trusted source to provide to loyal grain producers on credit to ensure supply of grain of superior or specific quality. Lastly, individual farmers sometimes produce and offer seed of local varieties to meet local demand, but without certification (which under the new seed legislation is no longer legal).

Thus, the structure of Mali's seed market is diverse, with farmer groups and cooperatives being important actors that operate in a decentralized manner within their geographical areas, with or without support provided by

³⁹ Source for cultivated area: average of years 2010-2014, FAOSTAT data, see Section 5.1.1; source for amount of certified seed available: Ministère de l'Agriculture (2016b)

⁴⁰ No published data available, information was kindly provided by the national seed laboratory.

development projects, NGOs, seed companies, grain traders or public breeding programs. Private seed companies participate mostly in large-scale deliveries of certified seed to government programs, NGOs or development projects.

Government agencies, such as the semi-autonomous *Office du Niger* (ON), and the now semi-privatized cotton company *Compagnie Malienne pour le Développement du Textile* (CMDT), have played important roles for agricultural development and seed dissemination in areas where they are active. For example, CMDT has promoted intensive maize production in cotton-growing areas by facilitating access to fertilizer and seed since the 1980s, and ON has been involved in the dissemination of high-yielding rice varieties, e.g. by providing information on varieties and production practices, and input credits.

5.1.4 FOOD AND SEED AID (MALI)

Food aid in Mali is organized by the government on a regular basis, based on analyses of vulnerability to food insecurity that are conducted in the months of March and April of each year. The main measures taken include free distribution of grain in areas affected by food insecurity during three months of the 'hungry period', government purchases to stabilize grain prices and/or build up a strategic reserve, and 'social sales' at reduced prices. The Malian government coordinates and implements these activities through its food security agency (*Commissariat à la Sécurité Alimentaire* (CSA)). In the years 2013-2016, a total of 30,000-350,000 t of cereal grains were distributed directly each year, or stored as reserve to fill local food security stocks, by the Malian government or partnering NGOs.

In recent years, and particularly since the last severe food crisis in 2004/5, the FAO as well as governments of partner countries, directly or via NGOs, have been involved in food aid activities in Mali. There are, for example, a great number of school feeding programs, run by the WFP, UNICEF and many NGOs, mainly in the northern regions of Mali. These programs are not expected to exert any influence on seed systems. However, some NGOs distribute a 'seed protection ration', which means that food aid is provided to avoid that people in need consume their stored seed grain (see also Section 4.1.4). One important finding of an assessment of seed system security (SSSA) in Douentza district, was that food aid (rather than seed aid) could be a key activity to ensure seed system security in stress-prone areas, where farmers rely nearly entirely on narrowly adapted local varieties (CRS/Mali and Partners, 2006).

In general, seed system security was found to be high in this study; even in difficult situations, e.g. drought and locust damage, most farmers managed to keep their own seed, particularly of cereals like pearl millet and sorghum; for these crops, only 2-3 percent of the harvested grain has to be saved for the next sowing period. For legumes, a higher proportion of the harvested grain is required, and there are generally more problems with storage pests (CRS/Mali and Partners, 2006).

The Malian Government actively supports agricultural production, with about 15% of the total budget⁴¹ (47 billion FCFA, equivalent to approx. 84.9 million US-\$) being spent for this purpose. Agricultural input subsidies, including seed, fertilizer and machinery, are a major share of this state expenditure. Farmers or farmer cooperatives can apply in advance for subsidized inputs in order to purchase them at reduced prices. However, seed is only occasionally distributed through this channel, and if so, it was mainly hybrid seed of maize in recent years (2012: 10 t; 2013: 17 t), while fertilizer was distributed on a regular basis in the period 2008-2013 (Ministère du

⁴¹ <http://www.librefrique.org/kramo-subventions-mali-010716> (28 July 2017)

The seed renewal (“renouvellement de semence”) initiative implemented by the WAAPP Program was politically decided, with the stated goal of replacing 12% of Malian farmers’ seed with “new” seed. “Winners” of this intervention were the large scale for-profit companies capable of obtaining government contracts, and seed producers (farmer cooperatives of various sizes) that had not targeted local seed sales. The seeds were delivered late, mostly unlabeled even without variety names, nor the names or contacts for the seed company, nor the seed producer organization. Some farmers receiving the seed for “rejuvenating their stocks” were actually hurt when poorly (or un-) adapted seed lead to yield reductions or total losses. Negative longer term consequences for seed producers and sellers are however likely as this action sets back efforts to build local seed sales networks.

Développement Rural, 2014). Some years ago, the Malian government also subsidized seed of NERICA⁴² rice varieties, as part of their development strategy for the rice sector (Ministère de l’Agriculture, 2009).

‘Seed aid’, in the form of free seed distribution, is further provided by the Western African Agricultural Productivity Promotion (WAAPP) program via WASP, both funded by international donors, e.g. World Bank and USAID. The International Red Cross Committee (*Comité International de la Croix Rouge* (CICR)) and FAO are also involved in seed distribution, focusing on the regions in northern Mali, affected by the security crisis since 2012. WAAPP/WASP distributed between 1,000 and 3,800 t of seed (free) in each of the recent years; FAO distributed smaller amounts, between 15 t (cowpea) and 155 t (rice) within the last five years, and the CICR distributed 13.3 t in 2015 and 6.8 t in 2016.⁴³ Hence, WAAPP/WASP was by far the largest supplier of ‘free seed’ in Mali in recent years; compared to the total amount of certified seed of important

staple crops available in the country (see Table 8), these amounts are considerable. Hence, an important share of the certified seed that has been produced in recent years was not sold, but distributed by the above-mentioned organizations.

5.2 RESULTS FROM INTERVIEWS WITH INDIVIDUAL SEED SYSTEM ACTORS IN MALI

The results from interviews with seed system actors in Mali for the same five major seed system functions as presented in Section 3.1 (Figure 1) are reported in this section.

5.2.1 ACTOR PERSPECTIVES ON THE LEGAL FRAMEWORK (MALI)

Regarding **variety release procedures**, the person managing the central seed laboratory and the national variety catalogue reported the successful registration of 249 varieties from the existing catalogue as well as some new additions into the digital regional West African catalogue, which now holds approx. 1600 varieties for the seven countries concerned.

Some of the breeders noted that the process of documentation did not differentiate clearly between the person providing the list of varieties, the breeder and their institution involved in the variety development process, and

⁴² New Rice for Africa (“NERICA”) is a group of high-yielding rice varieties derived from crosses between African and Asian rice, developed by the Africa Rice Center (AfricaRice).

⁴³ There are no published sources for these figures; information was obtained from the organizations’ offices in Mali.

Results (Mali)

the person/institution responsible for breeders' seed production. It was hoped that this can be rectified, because many of varieties in Mali are developed in partnership between several individuals and organizations.

Some breeders mentioned their discontent with the new procedures, which require that an independent authority conduct and evaluate the Value for Cultivation and Use (VCU). As Mali has very few trained plant breeders and technical resources for conducting such trials, the committee is testing a process, whereby the concerned breeders themselves conduct (or assist with conducting) the VCU trials and plant breeders from other crop programs assess and evaluate the trials. The breeder whose varieties were being evaluated using this new procedure did not approve the process, while another breeder appointed to the evaluation committee did not mention any problems with the procedure.

Another issue mentioned regarding the variety release procedure was that local varieties are not registered, and thus their seed cannot be certified for sale. Some farmers, as well as farmer organization representatives, wanted to ensure that certain local varieties can be disseminated more widely, using a more formalized approach.

Interviewees involved in the implementation of seed certification, both a field and a lab agent, expressed their concerns about the difficulties with correct implementation of the procedures, their costs, and the delays that are arising, while at the same time explaining the importance of applying the procedures. Seed producers observed that the agents did not always visit all the fields, and did not inspect the fields thoroughly, yet the fields were approved anyway. The field agents are also not equipped with Global Positioning System (GPS) monitors for precise documentation of locations and size of fields visited. In one case, a seed-producer cooperative really wanted to obtain "*the certification papers*", and had given seed samples for laboratory testing regularly, but never received a bill or the certification.

Some of the seed producers and their cooperatives complained about the cost burden of seed certification, whereas others had the fees paid by partners. Seed producer associations of the *Office du Niger* (ON)⁴⁴, for example, had the fees paid for them, and in other cases the seed companies that contracted them (or development projects supporting them) covered the cost. According to one Department of Agriculture field agent, "*a formula is needed for seed producers to be autonomous of projects, and sustain certification costs without project support*".

The certification costs were variable, sometimes said to be exorbitant, and not always transparent. For example the costs were reported to depend on not only the distance the agent traveled for field inspections but which regional office conducted them and its manner of billing. For example, agents from one regional office reportedly visited fields in several neighboring village cooperatives far from his headquarter, with all visits done on the same day, yet charged the full travel from headquarters to each village. Mali has the legal provision for local certification agents at the district level to lower certification costs, but even where these agents are present, they are not necessarily allowed by a regional office to conduct the inspections.

The major concern for the seed cooperatives and their members was the delay in receiving certification, even several months, which delayed when they could sell their seed. There was frequent mention by both seed producers and state certification agents of the need for decentralized laboratory services to lower costs and increase efficiency and speed of seed certification. Full implementation of new laboratory procedures still awaits a ministerial decree approving their application. The funds for the functioning of the national seed committee are not yet available either. This affects also the installation of the new equipment for the regional seed testing laboratories. According to the manager, even the central seed laboratory has not been officially created yet. This, as well as funding for buildings and training of staff, are necessary before the regional labs can be established.

⁴⁴ ON is a semi-autonomous government agency in Mali that administers a large irrigation scheme in the Ségou Region. More information: https://en.wikipedia.org/wiki/Office_du_Niger (27 April 2017).

Whether seed is certified or not is generally not visible when it is sold, as only rarely does the certification agency provide labels for attaching to seed bags. If labels are provided, the number is limited to two labels per 50 kg bag. Labels do exist, however, and we observed how the agent was labeling foundation seed of a maize OPV jointly with the breeder.

The possibility to recognize the quality of farmer produced, non-certified, seed was out of question for one Agriculture Department official who declared that *“only certified seed is seed”*. On the other hand, members of a women’s seed-producer cooperative practiced rigorous self-control, for which they enjoyed a strong reputation for quality seed. Farmers came from a large radius to buy seed from this particular cooperative and the Malian regional research station purchased seed from them, yet they never received certification papers. The cooperative indicated that each year they provided samples for testing but never received certification papers or bills. They complained about not being officially certified as they were proud of the quality of their seed and wanted to have official proof of its quality.

5.2.2 ACTOR PERSPECTIVES ON VARIETY DEVELOPMENT (MALI)

The ‘variety development’ seed system function entails activities such as genetic resources management, plant breeding and variety release. Information provided by interview partners on these activities are presented in this section.

GENETIC RESOURCES MANAGEMENT

The genetic resources unit of IER holds samples of national collections of sorghum and pearl millet, as well as other crops, in deep freezers. The catalogue is being digitized, and shall become searchable on the internet. The group of scientists is actively engaged in on-farm conservation activities with several local and international partners.

The pearl millet genetic materials used by the national program are based on germplasm collected in Mali and held at IER, as well as through collaboration and inputs from regional collaboration with other national pearl millet programs and ICRISAT.

The IER sorghum breeding program reported exchanging genetic materials with partners and having some working collection of local varieties. However, the only seed storage facility is an air-conditioned room with frequent power cuts, such that longer term storage of genetic materials is difficult. There is no clear identification yet of different pools required for hybrid parent development.

The germplasm for the maize breeding program comes from IITA and CIMMYT. A rice breeder indicated that the source of germplasm used in the program was from the Africa Rice Center (AfricaRice), based in Cotonou, Benin, and from the International Rice Research Institute (IRRI).

BREEDING

Pearl Millet: Science-based breeding is done by the IER Pearl Millet Improvement Program, which is based at the Cinzana Research Station of IER near Ségou, where mean annual rainfall is around 600 mm. It is using recurrent selection procedures for the development of new OPVs.

The development of the first pearl millet hybrids in Mali is the innovation for which the IER Breeder is most excited, a work that began eight years ago. Hybrids based on the OPV ‘Toronio’ were said to have shown more than 30% yield superiorities over the local variety in over 100 on-farm tests. These hybrids target the Sahelian zone corresponding to our study region of Ségou and as far north as Mopti. This and all other breeding activities are dependent on project funding. The selection for improved nutritional quality of grain (iron, zinc and protein) and for improved forage quality of stover, was recently initiated under the collaborative research initiative ‘Sorghum and Millet Innovation Lab’, funded by USAID under its ‘Feed the Future’ program. Further breeding work

on *Striga* resistance, and on combining downy mildew resistance, *Striga* resistance and long panicle traits, is done with support from the McKnight Foundation's Collaborative Crop Research Program (CCRP).

"The crowning achievement is hybrids, pushing up yield with Guinea-race [local type] grain, with these hybrids now in diffusion and many farmers trained in seed production."

A sorghum breeder

Sorghum: The IER sorghum breeding unit, part of the IER Sorghum Improvement Program, is based at the IER-Sotuba station near Bamako. The program is actively developing its own breeding material for development of pure line varieties and hybrids. It is also collaborating with ICRISAT and national programs in neighboring countries. For example it is creating its own male and female parents for hybrid development, and

contributes to a regional project on exploiting heterosis⁴⁵, led by ICRISAT. Several new hybrid seed parents with Guinea-type grain and lax panicles are now undergoing sterilization, a step needed for hybrid seed production in sorghum. Current efforts for male-parent development use introduced germplasm (Ethiopian materials and a type called 'Gadiaba' (Durra)) and diversified backcross-breeding products.

Farmer participation was said to occur at all levels of the breeding program. Preliminary agronomic testing of 150 lines is done on-station, with farmers invited to come and give input. The on-farm participatory variety testing involves collaboration with NGOs and farmer organizations. The breeding program also collaborates with the IER Food Quality Laboratory for testing new materials.

The objectives of the IER sorghum breeding program have changed considerably to respond to farmers' interests and needs: *"Greater attention is given to Guinea grain, as the introduced Caudatum grain is more floury and of poor quality for Tô [a common local dish] and stores poorly"*, said one breeder. The IER sorghum program is also concurrently developing dual-purpose, grain plus fodder, types for enhancing total value of sorghum.

Although most of the current projects are coming to an end, the breeder says *"we will find a way to continue developing hybrid parents"*. Yet, finding a way to maintain the breeding activities in spite of the imminent end of many current projects was said to be a serious concern.

Maize: The IER maize breeding unit is also based at the IER-Sotuba station. Field activities are conducted at Sotuba and Yanfolila, south of Bamako, as well as Finkolo and Farako, both near Sikasso.

A major topic being pursued is the breeding of top-cross hybrids, with one parent being a population. The yield superiority these hybrids are expected to provide is 20% over the established OPV 'Sotubaka'. The program has collaborated with IITA and CIMMYT, and is using their germplasm. It is also working on improving the β -carotene content of maize (a vitamin A precursor) to improve nutritional quality, in collaboration with IITA. However, other breeding activities that address grain quality aspects are not pursued. The IER sorghum, pearl millet and maize breeding programs are presently receiving funds from AGRA.

Rice: The IER breeding for the irrigated rice ecologies of Mali is based at Niono. Pedigree breeding methodologies are being used to develop breeding lines and experimental varieties derived from their own crossing program, with yield testing started in the sixth generation (F6). Participatory breeding is conducted in cooperation with AfricaRice. Around 100 new varieties are evaluated on-station and by farmers, with the 30 best chosen for testing the second year. In the third year, ten varieties chosen by farmers are evaluated in all seven zones of the ON (ten tests for each zone), as well as in Sélingué, San, Baguinéda and other irrigated rice-growing areas. One year of adaptation trials with the best three varieties and taste tests are conducted prior to submitting them as entries

⁴⁵ Heterosis, also called 'hybrid vigor', is a biological phenomenon occurring in the first generation of offspring (F1), if genetically distant lines of a plant species are crossed.

for registration trials (VCU, DUS), and initiating seed production based on farmers' choices. *"We have really made progress with reducing the time it takes us to release and disseminate new varieties"*, stated the breeder.

The breeder further reports that progress has been made for disease resistances (especially regarding Rice Yellow Mottle Virus), and cold tolerance such that rice performance in both seasons was improved. The program contributes experimental varieties to a regional collaborative testing program, and has access to materials from AfricaRice and collaborating national programs. The IER-Niono program has also started its own hybrid breeding program with materials from IRRI.

The IER breeding program for upland and lowland rainfed rice is based at Sikasso. This program was not visited for this study, given the limited timeframe. The program for rice grown under natural submersion conditions is based in Mopti, but does not have an active breeding program.

Farmers routinely select in their local varieties, with major importance given to environmental adaptation and grain quality traits, besides yield. Both men and women frequently mentioned the importance of adaptation to low soil fertility in Mali for all cereal crops.

VARIETY RELEASE

Mali is in the process of implementing a new system for varietal release as part of the regional seed legislation harmonization activities. One IER breeder engaged in initiating its use reported that it takes more time and is

"The new system is really cumbersome. The team that was especially trained for this does not really know enough about the crops. Our team was the first one to try the new system, but it was a lot of effort to get all the necessary data for the regional catalogue. We hold a lot of meetings, wasting a lot of time, and resources."

A plant breeder

more costly than the way that breeders previously submitted new varieties with their description (*"Fiche Technique"*) for inclusion in the national catalogue. Another IER breeder said that the *"new text"* is there but that they were not yet implementing it — which he considered to be advantageous (see box).

One breeder mentioned the cost for registration, acknowledging financial support from the *Institut du Sahel* (INSAH) for the recent registration of many varieties and parents, but also regretted the delay that was caused through the

new procedures: *"Now it is obligatory to pass through DUS for one year and VCU, taking a minimum of two years."*

The 2016 National Catalogue of Mali lists 20 pearl millet varieties, of which ten varieties have intermediate maturity duration (100-120 days), which corresponds to the requirements for the zone of Ségou, where the Malian pearl millet breeding program is located.

Four varieties are earlier (<100 days) and six are later maturing (125-150 days). Varieties that are less than 20 years old include early (1), intermediate (6) and later maturing (2) entries. Half of the varieties listed in the catalogue are described as being tolerant to Downy Mildew (*Sclerospora graminicola*), the fungal disease that is the most serious biotic constraint for pearl millet.

A total of 54 sorghum varieties are listed in the 2016 National Catalogue, 41 of which were registered in the last ten years, and includes 11 hybrids, 33 bred OPVs and eight landrace-derived OPVs. These varieties represent a

Among the varieties dominating current seed production activities for all crops, several were released a relatively long time ago. The two rice varieties for submerged (flooded) conditions, 'Khao-gaewn' and 'DM16', were among the oldest varieties, developed in 1987 as per the 2016 Malian catalogue. The variety ages differed widely for the major rice varieties for irrigated production: 'Adny 11' (1987), 'Gambiana' (1994), 'Wassa' (1998) and 'Nerica L2' (2007). For rainfed (lowland) conditions, the varieties 'BW348-1' (2011) and 'Shwetaskoké' were produced. All rainfed (upland) rice varieties were inscribed in 2002 or more recently. About half of the total volume of sorghum seed produced nationally is now of hybrid varieties, all of which were released after 2009. For pearl millet, the dominant variety produced as certified seed is 'Toronio', released in 1994.

range of panicle types (28 lax panicles and 26 compact or semi-compact), and plant heights (15 short, 18 intermediate and 21 tall), where tall height and lax panicle correspond to the local variety plant type and shorter height and semi-compact or compact panicles represent new plant types, including novel dual-purpose grain and fodder types.

The National Catalogue lists 46 maize varieties, over half of which (24) were registered in 2014. The listed varieties entail 26 OPVs and 20 hybrids. The grain type recorded is predominantly flint (33), followed by flint-dent (8), floury (2), and sweet, dent, and semi-flint (1 each). The OPV varieties 'Sotubaka' (from 1995, yellow semi-dent grain type) and 'Dembanyuman' (from 1998, white floury grain type) are currently the most prevalent varieties.

For rice, 57 varieties are listed in the Catalogue, of which about half were registered between 2011 and 2015, with the remainder registered between 1987 and 2007. Among the 57 listed varieties,

a total of 31 varieties were classified as appropriate for irrigated production, 14 for rainfed-lowland and only two for submersion. Twelve upland (rainfed) varieties completed the list. The grain length of released varieties was evenly split between long and medium length, with only three being short grained. Two varieties are local varieties, listed as "Population locale", and the remainder are pure line varieties.

5.2.3 ACTOR PERSPECTIVES ON SEED SUPPLY (MALI)

The 'seed supply' function of seed systems includes provision of early generation seed, seed production and processing, and seed quality issues.

PROVISION OF EARLY GENERATION SEED

Seed producers in Mali generally obtain the foundation seed for sowing their seed production fields from public institutions, e.g. various IER stations or sub-stations, and the 'Office Riz Mopti', which is involved in promoting improved rice cultivation practices. One breeder reported that early generation seed is multiplied at the research stations with support from projects; this helps generate some income for the stations. However, farmer seed-producer cooperatives have recently begun to produce foundation seed for sorghum, maize and millet and have done so for several years for rice. "We have progressed", was the comment of the office holder for the Federation of Seed Producers.

Difficulties in obtaining the quantity of foundation seed desired or obtaining it on time were only rarely mentioned. Problems of the quality of foundation seed was mentioned only infrequently in specific cases, e.g. particular sorghum hybrid parents, and rice varieties.

Furthermore, there was mention of lack of demand for foundation seed of newer varieties that are less known. The reported farmer practice of using foundation rice seed directly for grain production, rather than certified seed (R1 or R2 in the notation used in Mali), was judged to be a "misunderstanding" by a representative of the

'Direction de l'Agriculture-Mopti', whereas the farmers practicing this, especially in Niono, mentioned reasons such as "better performance" and "higher level of genetic purity", which is related to the price paid for the grain.

SEED PRODUCTION

Certified seed in Mali is almost entirely produced by farmer seed-producer groups. These groups include associations, cooperatives, *Groupes d'Intérêt Économique* (GIE), a Malian specific legal business entity, exempt from some taxes, and women GIEs (*GIE femmes*). The Malian government has long supported seed supply activities and farmer seed-producer groups (see box). These groups may organize input supply on credit, and at least for rice in Niono, were reported to work with local banks and microfinance institutions. Some private seed enterprises produce a small portion of their total seed volume on their own land, mostly for varieties or hybrids that require specific attention for seed production. The larger part of the seed produced by these companies is via direct purchase from the aforementioned farmer-seed producer groups, mostly without prior contracts.

Seed production is conducted almost entirely in areas where the varieties are well adapted and currently being grown for grain production. Off-season seed production, e.g. in other areas, was not mentioned in interviews; however, it exists to some extent on irrigated land managed by seed companies⁴⁶.

"The governmental 'Service Semencier' gave inputs, basic seed, arranged for certification and bought the seed from the group. The Seed Sector Support Project (PAFISEM) then supported the Service Semencier as the state disengaged and transferred these roles to seed cooperatives, limiting its involvement to technical support."

President of a farmer seed producer group founded in 1988 in Mopti.

There was some mention of production of grain to be used as seed by others in the village by individual farmers who are locally recognized and respected for the quality of their grain. These individuals produced highly appreciated local varieties and, in some cases, certain new researcher-bred varieties. Individual rice farmers in Niono reported buying certified foundation seed from the research station with they use to produce seed, but without certification.

Representatives of farmer seed-producer groups all indicated in interviews that their choice of varieties to produce reflected farmer

demand. This was most evident for rice, with repeated mention that the "farmers come to us for seed". Several groups also mentioned that they met to discuss and decide which varieties to produce. Although large seed companies buy seed from farmer seed-producer groups, contracts for production are normally not given and companies mostly expressed their interest to purchase seed only after the harvest (and certification), and as such had little direct influence on which varieties farmers produced. However, we were told of one larger agrodealer who provides the foundation seed, as well as other inputs and covered certification costs on credit for seed producers. Several farmer seed-cooperatives are producing hybrid seed of sorghum, and some cooperatives also produce the foundation seed of the parental lines.

Very few women are involved in cereal seed production, as they have even greater difficulties than men to assure isolation, especially for pearl millet, due to the smaller size of their fields. Furthermore, women mentioned that the low soil fertility status of their fields hindered them from producing seed. However, there was also one successful women's seed-cooperative producing large seed volumes of many varieties of rainfed (lowland) rice; a crop traditionally considered to be a women's crop in Mali.

⁴⁶ Personal communication via e-mail, Dr Issoufou Kapran (AGRA), received on 31 May 2017.

SEED PROCESSING

There were two predominant models for conditioning (cleaning, but generally no treatment) and packaging seed in Mali; centralized with imported high-capacity equipment and geographically decentralized with predominantly manual methods. The centralized model is used by seed companies (or more precisely seed traders) located in the capital city and in some cases relying primarily on grants to purchase their seed processing equipment with which they condition seed purchased from seed-producer groups.

The decentralized model involves individual farmer seed-producer cooperatives who, primarily using traditional practices and locally made sieves, and small-scale packaging equipment to process and pack seed that their members produce. For rice, locally fabricated mechanical cleaners exist but are not much used, resulting in seed conditioning (sorting) being a real problem and seed often getting rejected for impurities.

Several farmer seed-producer cooperatives named seed conditioning equipment as a priority for their future development, although often with the idea that it might be given by a project. However, one cooperative realized that it could arrange to equip itself directly using cooperative funds (currently collecting 10 FCFA or less than two US-\$-cent per kg seed sold).

Most certified seed was sold without seed treatment. This enabled seed businesses to sell unsold seed stocks as grain and not carry-over unsold seed stocks, thus minimizing risks of selling seed with low germination capacity. However, all rice seed in Niono was reported to be treated. The farmer seed-producer cooperatives in the driest part of the study area, east of Douentza, are considerably increasing their treatment of pearl millet seed for local sale in response to farmer's demands. Farmers' appreciation for seed treatment was frequently heard with comments such as *"Apron Star⁴⁷ is very effective; I no longer need to resow"*; such statements were made by both women and men, in remote as well as more accessible locations. Furthermore, farmer seed-producer cooperatives are selling increasing amounts of the 'Apron Star' treatment for farmers to treat seed of their own local varieties.

Certified seed of sorghum and pearl millet was sold primarily in clear plastic packages of 0.5, 1 or 2 kg. These packages were heat-sealed; labels included information such as variety name, name of the producer organization and typically some indication of varietal adaptation. A few seed businesses are also producing larger packages of 4 to 5 kg, mostly woven polyethylene sacs, for farmers interested in buying larger quantities. Cooperatives producing rice seed sell seed in unlabeled 50 kg bags, but the name of the variety, of the seed producer and usually his phone number are hand-written on the bags.

The maize seed sold by agrodealers in the main maize production regions (Sikasso and Koutiala) was mostly sold without packaging or seed treatment. However, one seed seller representing a company sold maize seed that was packaged by the company in Bamako. Seed of pearl millet and sorghum sold by the same agrodealers was all packaged, but without certification labels.

The storage of seed by farmer seed-producers and cooperatives was mentioned as a problem that needed to be resolved. Storage of seed at the homes of individual producers is common where warehouse facilities are absent, and this was indicated as a concern for quality as well as making sampling for laboratory testing more difficult; furthermore, there is increased risk that the seed would be consumed as food grain.

⁴⁷ 'Apron Star' is a seed treatment product of Syngenta, protecting seedlings against soil- or seed-borne fungal diseases, such as downy mildew, as well as against early-season insect damage.

SEED QUALITY

In Mali, poor germination and mixed or fake seed were rarely mentioned by farmers in interviews; the only exception were complaints regarding varietal purity for rice seed. Therefore, rice farmers sometimes used foundation seed for grain production despite the much higher price of this seed (see above under ‘provision of early generation seed’).

However complaints about impure, mixed seed, and ‘fake’ seed (seed not corresponding to the purported variety) were raised by farmers who had received free seed distributed by the WAAPP, an initiative aiming to “rejuvenate” farmers’ seed stocks with funding from the World Bank.

Some farmer-seed producers and cooperatives producing non-certified seed for local sale reported exercising strong self-control for seed purity, e.g. self-rejection of production fields in rice when presence of virus diseases was observed (mentioned by a respected individual farmer seed producer in Niono), or in cases of variety mixtures observed in the field (mentioned by members of a cooperative in Sikasso).

Pearl millet farmers reported that the quality of their own pearl millet seed was compromised by outcrossing with millet varieties introduced or demonstrated by several development projects. These farmers said they could no longer produce pure seed of their local variety as it was now mixed or hybridized (“métissés”).

Further issues that were raised by seed certification agents include:

- Detailed variety descriptions are needed to facilitate clear identification of specific varieties
- Better trained staff, e.g. able to recognize specific varieties, or to differentiate between genetic variation and variability due to environmental differences
- Improved means of transport for field inspections and seed sampling
- Field inspectors often come after flowering of the crop, but should come before, to avoid contamination by rogueing off-type plants or other varieties.
- Need for regional seed testing laboratories to reduce delays in seed certification

5.2.4 ACTOR PERSPECTIVES ON SEED DISSEMINATION

‘Seed dissemination’ includes aspects such as distribution channels, information flow, financial management as well as seed prices, costs and risks.

SEED DISTRIBUTION CHANNELS

Most cereal farmers in Mali have little previous experience with seed purchase except for farmers who grow irrigated rice. When asked “*what would your neighbors say if you went to buy seed?*” the answers presented often reflected traditional negative connotations relating to purchase of seed for traditional staple cereals (see box on next page).

It is thus not surprising that in Mali, farm-saved seed was the most common source of seed for all cereals. Irrigated rice farmers more often buy certified seed yet they may do so only every third or fourth year. Reliance on ones’ own saved (and often selected) seed was particularly widespread for smallholder farmers and women. The same was true for the other dryland cereals, for which farmers widely reported producing their own seed of improved, released varieties.

However, farmers are purchasing certified sorghum, pearl millet and maize seed in the Koutiala and Sikasso areas, and to some extent in Ségou, especially near the city. The statement of a representative of a federation of seed producers in the Sikasso region (see lower box) makes clear that commercial dissemination of certified seed is a new and evolving undertaking.

In the region north of Mopti, female farmers responded to the question “What would the neighbors think if you bought seed?” that their neighbors would have the impression that “I didn’t work”, or that “I didn’t assume my responsibilities”, and men farmers spoke of it being seen as “a sign that I don’t have seed” or that “the family is destroyed”.

“Earlier, the farmers didn’t buy seed, every farmer kept their own seed. Now they appreciate quality seed... many farmers here buy seed on their own, without any support”

A member of a federation of seed producers, Sikasso region

Farmers who purchased certified seed most frequently obtained it from farmer seed-producer cooperatives in their area. Trust was raised as a key factor regarding choice and source of seed. For example certain farmers stated that they would never renew their seed from outside of their village as they wouldn’t know if it was adapted or not. One farmer flatly stated that he would never buy seed coming from Bamako (the capital of Mali).

Another form of trust was knowing and respecting the seed producers for the quality of their seed. Several seed cooperatives were particularly known for the quality of their seed. One agrodealer in Niono told how she specifically advertised from which farmer-cooperative she obtained the seed she sold, as it was respected for its high quality seed. Among the 24 farmer seed-producer cooperatives interviewed, all but one indicated that they market seed directly to other

farmers in their areas. Farmer seed-producer cooperatives and associations are widespread in each of the four regions examined in this study; four to nine being interviewed per region.

Often the clients go directly to the cooperative to purchase seed. The cooperatives also used diverse modes of sale to achieve even greater proximity to buyers. Several cooperatives organize additional sales points, including in weekly markets in their village, or in neighboring villages. Although organizing multiple points of sale was recognized as a way of increasing sales, it was also seen to incur expenses. One seed-producer group maintained 17 sales points in 2014, but the following two years, with large consignments of seed purchased for seed distribution programs, they drastically reduced their points of sale. The cooperative east of Douentza plans to buy a motorcycle delivering smaller orders of seed in the widely dispersed villages in the area north of Mopti. Other modes used by the cooperatives for selling seed to farmers included: cooperative representatives that sell seed on commission in several villages; sales through or with assistance of NGOs and the regional department of agriculture, and by agrodealers who purchase the cooperatives’ seed for sale from their shops.

The proportion of the cooperatives’ seed that was sold directly to farmers’ in their area was typically much less than the volume sold to large buyers, e.g. seed companies or NGOs, especially in the last three to four years in which large-scale free seed distributions occurred. The relative proportion of seed sold directly to farmers is considerably higher for rice than for the other three cereals.

For pearl millet and maize, both highly cross-pollinated crops, several farmers who grow improved varieties (mainly for maize) reported that they regularly purchase small quantities of certified seed, to mix with their own selected seed, with the aim to “refresh their seed”. Pearl millet farmers in the Ségou area, where the variety ‘Toronio’ is widely grown, explained how they are actually maintaining a diversity of plant and panicle types in their seed lots.

Only two men among all the farmers we interviewed (91 interviews with 106 men and 34 women) had ever bought seed from agrodealers or seed company retail stores. One of them also worked as a grain aggregator for grain traders in Sikasso and Koutiala, and the other was a larger farmer near Koutiala, with both having bought hybrid maize. Some representatives of seed companies reported that direct sales to farmers constituted approximately 20% of their sales, concentrated around the larger cities, where particularly middle-class individuals invest in intensified agricultural production.

The agrodealers interviewed in Koutiala, Sikasso and in Markala (Ségou region) sell cereal seed as well as other inputs such as fertilizers, herbicides and pesticides. There are no agrodealers in the Mopti region, according to an Agro-enterprise Project Manager for a major NGO, and we also did not encounter any agrodealers selling seed

“Adoption is fast now... now, with increased proximity of seed to the farmer, the change is visible”

A NGO project manager based in Koutiala

in the Niono region. All the agrodealers in Koutiala and Sikasso sold maize seed and some also pearl millet, rice and/or sorghum seed. Only one sold hybrid maize of a variety called ‘Américain’, obtained from an Agricultural Input Supplier, and the volume of sale was much less than for OPV maize. The agrodealer in Markala mostly sold rice seed. The agrodealers in Koutiala and

Sikasso mostly only sold seed from their shop in town, and the clients came mostly from nearby. Some also had retailers in other towns who ordered seed or received orders passed through the regional agriculture department offices.

The agrodealers obtained their seed entirely or mainly from farmer seed-producer cooperatives, and some directly from IER. The agrodealer in Markala provisioned her seed from a single cooperative which is highly trusted by farmers. One agrodealer reported that the seed, purchased from a nearby farmer seed cooperative, was processed, packaged and labelled manually at his shop.

In some instances, farmers received certified seed (purchased from a farmer seed cooperative), especially of rice, and in some cases of sorghum or maize, from a grain trader, or a grain processor on credit basis, whereby the seed price was deducted from the grain value at harvest.

Individual farmers who are recognized in their area for the quality of the seed they produce sell, exchange or give seed to other farmers in their area. This seed is not certified, but buyers know the producer and have confidence in the quality of his or her seed. The types of varieties produced by these farmers included released varieties, varieties chosen by farmers in participatory variety evaluation that were not yet released and local varieties. Seed obtained from individual farmers in the irrigated rice area was mostly purchased, as seed quantities required are high. Seed of pearl millet or sorghum, however, was mostly given for free or exchanged for a similar volume of grain.

Some farmers reported receiving training on testing new varieties from research or other farmers and subsequently multiplied their own seed of preferred varieties. Development project activities included varietal trials, demonstration plots and Farmer Field School activities. Several interviewees reported how these activities in the past decade have led to large-scale adoption of new pearl millet and sorghum varieties.

Farmers who participate in on-farm testing of varieties usually keep some seed of their preferred varieties. For rice, they start reproducing varieties from the first trials, and the seed starts circulating. According to the IER breeder, this system work works very well. Farmers’ widespread activities of saving seed, selecting, and exchanging seed, were evident. One rice farmer, a man from Niono, said: *“I normally buy seed of a new variety just once”*.

One specific case of farmers’ regularly purchasing seed of a dryland cereal is for pearl millet in the very dry part of Mopti region, where they purchase from local farmers recognized for the quality of their seed. These local seed providers from three neighboring villages have formed a seed-producer cooperative to sell their local variety more widely. Their pearl millet variety (‘Tabi’) is widely appreciated for its adaptation to the dry and highly variable rainfall conditions, as well for its resistance to ‘head miner’, a serious insect pest in this area, and its grain quality (recently confirmed to contain high iron and zinc concentrations sufficient to be classified as ‘bio-fortified’). As this is a local variety, it is not registered in the national variety catalogue and its seed cannot be certified, in spite of it being highly appreciated and purchased by farmers.

Results (Mali)

Development programs targeting increased agricultural production have started to engage in the dissemination of new varieties. In addition to the farmer variety testing mentioned above, some programs conduct larger scale distributions of free seed to farmers for sowing areas of about 0.25-1.0 ha with a new variety that was previously tested in the area. This approach was said to facilitate many farmers getting a chance to actually try a new variety on a production field, without the financial risk of seed purchase.

The distributions of seed for emergency relief has been very rare in Mali before the 2012 political crisis⁴⁸. Private seed companies reported that in recent years, their sales of seed through large contracts, where the seed is being distributed free to farmers in specific target regions, has increased significantly. An important shift for some companies has been the growing importance of rice seed distribution, as there is a focus on supporting farmers in interior Delta region of northern Mali, where new irrigation perimeters are being completed, or if they are affected by the ongoing crisis.

The government of Mali, through the WAAPP, has initiated a national effort for the 'renewal of farmers' seed' for a wide range of crops with the target to cover at least 12% of the cropped area in Mali (section 5.1.4). The seed companies were awarded contracts on short notice to supply specific areas of the country with this seed, and to reach specific districts. Government extension agents, mayors' offices and some of the seed cooperative members reported that they had been tasked to receive and distribute the seed to farmers in their area, and organize the recuperation of a quantity of grain equal to the seed received for use as seed the following year. Difficulties reported with this distribution included that the seed arrived late with little or no description of the varietal characteristics, and in some cases not even the variety name. Some farmers suffered serious production losses by sowing such seed that was not adapted to their location. In the Mopti region, our interviews of farmers and farmer seed-producer groups indicated that the volume of certified seed currently obtained by farmers was much more through the various distribution activities than through direct purchases.

INFORMATION FLOW

Information about what seed is available for sale and where was frequently mentioned as an issue. Announcements over local radio programs indicate where seed can be purchased. The seed-producer groups, who are selling seed, or public extension services, take responsibility for diffusing this information. Despite announcements being made on radio stations with wide coverage, some farmers still are not informed of where seed of certain varieties can be obtained. In addition, incidents were encountered of farmers who wanted to buy seed of varieties recently introduced through development project activities, e.g. Farmer Field Schools or demonstration plots, but didn't know where to obtain seed.

Seed fairs are being organized, for example, by the Malian seed producer association (*Association des Semenciers du Mali* (ASSEMA)) to link seed producers and mostly large scale seed buyers. A national seed fair has been conducted for a few years and regional fairs have just begun. One farmer suggested that farmer organizations not involved in seed production need to be better informed of seed availability.

Information about where specific seed came from, the place, person and or organization producing it, was vital information for some farmers seeking to purchase seed. This was especially strong for pearl millet in Mopti and rice in Niono. An important marketing tool for one agrodealer was to advertise from which cooperative her seed originates, as farmers highly respected its seed. Most Farmer seed-producer groups label seed packages they sell with their name and location. The Federation of Seed Producers of the Sikasso Region is currently negotiating with the seed companies to include the name of the cooperative that produced the seed on each seed package

⁴⁸ This crisis refers to an ongoing conflict between armed groups in the northern parts of Mali and the Malian government, leading to a situation where the former president Amadou Toumani Touré was ousted in a coup d'état on 22 March 2012.

that they sell or distribute. Sacks of rice seed in Niono are labeled with the name and sometimes telephone number of the farmer who produced it.

Culinary tests of new sorghum hybrids were organized to relay fears of eating grain from hybrids and inform farmers that hybrids are not GMOs. The president of a women's seed-producer cooperative tried to combat the fear of hybrid sorghum by sowing the hybrid 'Pablo' in her field and inviting the heads of families to visit her field. Yet, fear of hybrid sorghum still exists in the village even though their own cooperative is producing the seed.

Organizing visits to the hybrid seed production field was discussed as a further way to explain hybrids and relieve fears. Local radio producers were also invited to field days and participatory variety evaluations involving these new hybrids to help spread information.

Sorghum hybrid varieties are new and many farmers think that they are GMOs, which is a serious concern for many (see box). Some interviewees commented that farmers are now "starting to understand hybrids" and demand is growing for sorghum hybrids due to the higher yields obtained. Maize hybrids were used by very few well-off farmers, and the comments received were more regarding the price of seed.

To describe the adoption pathway, farmers repeatedly stated that "new seed came, people tested it, and were convinced." Researchers' comments on the same issue also highlighted the importance of farmers' direct contact with new varieties, having their own 'hands-on' experience; one national program breeder said: "Farmers don't trust in things that they do not know".

Organized on-farm varietal testing was mentioned by farmers, plant breeders and extension personnel as being highly useful for obtaining information about the performance of new varieties. Farmers' access to results of on-farm varietal testing occurred in various ways; their direct involvement in testing, visiting test plots, discussions with farmers who were involved in testing, and through extension agents associated with the testing. Breeders involved in such activities noted advantages not only for effective seed dissemination but also for obtaining farmer feedback to strengthen their breeding program. National program cereal breeders called for "a communication strategy, including feedback from participatory activities", and "mobility of researchers towards farmers, and mobility of farmers towards breeders" as ways to improve their effectiveness.

Farmers and farmer seed-producer groups mentioned various types of varietal demonstrations they use to get or disseminate information about new varieties. These included demonstration plots, 'seed buyer plots' (a field sown by someone who had purchased seed and that is visited by others), and threshing place comparisons, i.e. of harvested panicles of new and local variety viewed side by side at threshing sites. Furthermore, field days and farmer-to-farmer exchange visits centering on demonstration plots or farmer field schools were mentioned as sources of information and as activities conducted by public researchers, NGOs, farmer seed-producer groups and extension agents.

One representative of a seed-producer association mentioned that they used radio and television for disseminating information on new varieties, and summarized: *“Actually, it is the farmers who gives the information to others”.*

“Earlier, breeders worked alone and we, the extension agents, simply had the role of putting the varieties in tests or demonstrations and the breeder alone was the one knowing the varietal characteristics. Now the research is participatory and it is the farmers who chose the varieties. This participatory method of extension facilitates adoption”.

An extension agent from Niono

Recommendations *“depending on the type of soil, the availability of labor”* to no recommendations what so ever as *“it is the shop owner who does that”* or *“they [the clients] know which varieties they want, or heard from other farmers”.*

For maize, the parastatal cotton company CMDT not only introduced the varieties ‘Sotubaka’ and ‘Dembanuyman’, but established maize as a major crop in southern Mali. Older men in villages told how CMDT, starting in the late 1970s, provided seed and fertilizer on credit, bought the grain at double the local market price and established mills for processing the grain. Our interviews with farmers in Koutiala and Sikasso indicated that these two maize varieties continue to be the predominant varieties cultivated until today.

The recent involvement of CMDT with sorghum seed is attested to by one farmer who spoke of a sorghum variety he called *“CMDT”*. Recent distribution of the new sorghum hybrids has also been undertaken with support from a development donor and research partners (see box on next page). The focus is on diversifying intensified cereal production by including hybrid sorghum in the production system.

“Farmers’ demand” was regularly mentioned as the basis for choice of which varieties to produce or sell. One agrodealer mentioned doing pre-season visits with his clients to better *“position himself”*. Some seed sellers, agrodealers and farmer seed-producer groups are recording the telephone numbers of seed buyers to enable follow up. Another agrodealer mentioned *“working in collaboration with the farmers”* to enable her to choose the varieties according to local demand.

Knowing farmer demand for specific varieties was noted to be essential for planning early generation seed production by a plant breeder, but was seen as a challenge (*“we don’t know the demand in advance”*). Another plant

Distributed seed samples sometimes offer farmers access to new varieties. For one farmer, aged 42, the CMDT distribution of the hybrid ‘Pablo’ was his chance to obtain seed that he had long been interested in, but his father did not approve of changing the variety; a situation not uncommon with his peers. He secretly sowed the hybrid and only showed his father when the large panicles were visible, after which the father was happy and approved.

breeder however reported their detailed process of participatory variety testing that concluded with farmers indicating their choices of varieties for seed production.

Responses from seed sellers in agrodealer shops on what information they share with prospective customers ranged from specific varietal recommendations

to no recommendations what so ever as *“it is the shop owner who does that”* or *“they [the clients] know which varieties they want, or heard from other farmers”.*

For maize, the parastatal cotton company CMDT not only introduced the varieties ‘Sotubaka’ and ‘Dembanuyman’, but established maize as a major crop in southern Mali. Older men in villages told how CMDT, starting in the late 1970s, provided seed and fertilizer on credit, bought the grain at double the local market price and established mills for processing the grain. Our interviews with farmers in Koutiala and Sikasso indicated that these two maize varieties continue to be the predominant varieties cultivated until today.

The recent involvement of CMDT with sorghum seed is attested to by one farmer who spoke of a sorghum variety he called *“CMDT”*. Recent distribution of the new sorghum hybrids has also been undertaken with support from a development donor and research partners (see box on next page). The focus is on diversifying intensified cereal production by including hybrid sorghum in the production system.

“Farmers’ demand” was regularly mentioned as the basis for choice of which varieties to produce or sell. One agrodealer mentioned doing pre-season visits with his clients to better *“position himself”*. Some seed sellers, agrodealers and farmer seed-producer groups are recording the telephone numbers of seed buyers to enable follow up. Another agrodealer mentioned *“working in collaboration with the farmers”* to enable her to choose the varieties according to local demand.

Knowing farmer demand for specific varieties was noted to be essential for planning early generation seed production by a plant breeder, but was seen as a challenge (*“we don’t know the demand in advance”*). Another plant

breeder however reported their detailed process of participatory variety testing that concluded with farmers indicating their choices of varieties for seed production.

Farmer seed-producer groups mentioned contributions of NGOs, public research and extension in providing training for seed production, marketing and financial planning and suggested further training as a priority for enhancing their functioning in the future: *“Strengthening capacity is critical – as we say in Bambara [local language]: instead of giving a fish, teach to fish”.*

Another seed-producer group suggested having good sharing of information among “partners” to avoid that all do similar activities with the same farmers.

FINANCIAL MANAGEMENT

Challenges of cash flow constraints were mentioned by farmer seed-producer groups. The time waiting to receive certification of their seed was said to delay seed sales. Also, late payments, after the start of the next year’s season, for large volume seed purchases by NGOs, seed companies or seed traders (using what they call ‘purchase contracts’) were reported to hinder seed producers’ purchase of inputs.

Some seed-producer groups are taking loans. The cost of credit, however, was reported to be “heavy” and banks lacked flexibility and understanding of agriculture seasons and the specificities of seed producers’ cash flow constraints and opportunities.

The costs of seed certification were mentioned as a problem in all areas, particularly in the Koutiala-Sikasso region. Arrangements for covering the certification costs mentioned included payment by the seed producer-group, on credit from a large-scale seed buyer, projects and support from extension services (see also above, Section 5.2.1). A department of agriculture agent noted that group financial management is not easy, and reinforcing capacities is important for longer-term development. Many of the seed cooperatives indicated these needs.

Individual for-profit seed enterprises have received funding and support from donors through seed projects, and/or international investment. Cash flow difficulties to bridge the long periods between harvest and seed sale, and between sale and receiving payments, were also mentioned by this group. They specifically suggested that banks needed to understand the nature of the seed market better, so that they can provide the appropriate support.

The recent government intervention in ‘seed renewal’, through the WAAPP has, over the past three years, created its own market (“*Marché WAAPP*”) that has “given oxygen” to seed enterprises, enabling complete sales of large seed stocks after several years of large unsold stocks. One seed-producer group that sold 70 t of seed to this ‘*Marché WAAPP*’ in 2016 was wondering what would happen this year.

Farmer seed-producer groups complained about being closed out of direct involvement in the state seed procurement as only the largest for-profit enterprises “have the papers” required. They also wanted to be involved in the negotiations as seed enterprises with the WAAPP. The seed producer-groups said that seed companies “ride on the back of farmers”. The seed company sells rice seed for 750 FCFA/kg, whereas it pays the producer 350 FCFA/kg.

The reliance of public breeding programs on project funding was an issue consistently mentioned. It was also stated that the sale of breeders’ seed cannot finance the breeding program, but can at least contribute, as mentioned by a rice breeder in Niono, for example.

SEED PRICES, COSTS AND RISK

“Rare are the people who can buy seed, it has its cost”, or “earlier farmers didn’t buy seed” were frequently heard statements of farmers in the rainfed areas, where pearl millet, sorghum and maize are produced. It was not possible from our interviews to report on the extent to which seed price *per se* or farmers’ cash liquidity limited their purchase of seed. What was repeatedly heard, however, was that earlier farmers did not buy seed, but now many buy at least some of their seed.

Some seed sellers mentioned differentially pricing seed. An agrodealer spoke of selling different qualities so that every farmer could buy at the price they can afford, as did farmer seed-producer groups as well. Seed-producer

Results (Mali)

groups reported selling seed locally at a reduced price in comparison to seed sold to NGOs or large seed companies or seed traders. Sale on credit basis was rare for direct farmer purchases from seed cooperatives, but it was facilitated at a large scale by unions of farmers' cooperatives who primarily engage in cooperative grain marketing.

Hybrid seed of maize and sorghum were higher priced than OPVs (Table 9). The higher price of maize hybrids was said to deter sales, and maize hybrid seed sales were much lower than for OPVs. Sorghum hybrids however are gaining in sales relative to OPVs, with total seed production now reported to be equal in volume to OPVs.

Table 9: Grain and seed prices stated in interviews (in FCFA, 1 US-\$ = 556 FCFA) and seed-to-grain price ratios for various crops and variety types in Mali, March 2017.

	Rice (irrigated)	Maize		Sorghum		Pearl Millet
Variety type		OPV	Hybrid	OPV	Hybrid	
Average grain price	150	100		125		150
Average price of certified seed	275	400	750	350	700	400
Seed-to-grain price ratio	2:1	4:1	8:1	3:1	6:1	3:1

No farmers' comments were heard regarding the price of sorghum hybrids, but comments like "*the farmers love greffage* [a local term used for hybrids]" and reports of farmers returning to seed-producer cooperatives to tell how they appreciate a new hybrid were heard.

The seed prices listed for Mali (Table 9) are mostly the prices that the farmer cooperatives charge other farmers for the seed. These prices include costs for the seed producer, for the cooperative, especially the persons who condition and package the seed, as well as those who market the seed. Similarly, some costs for packaging materials and advertising with the local radio stations are included.

When selling seed in bulk to seed companies or development projects (see above), seed producer cooperatives can generate additional income, since they get better prices in spite of having less cost. The companies, in turn, sell the same seed at even higher prices to NGOs or projects, partly to cover costs for transportation, packaging etc. However, we could not get any precise information about these different seed prices.

5.2.5 ACTOR PERSPECTIVES ON SEED SYSTEMS IN RELATION TO CROP PRODUCTION AND USE

Information provided by seed system actors on 'crop production and use' includes aspects of adaptation and risk, on-farm processing and use, and market demand.

ADAPTATION AND RISK

"*Adaptation to the zone*" and "*time to maturity*" were key characteristics that farmers of all four cereals mentioned when discussing the varieties they grew and their specific advantages or disadvantages. Adaptation to the zone was most strongly mentioned in the Mopti and Ségou regions. The adaptation to specific depths of water was critical for lowland rice, and tolerance to drought was mentioned for all crops, especially in Mopti.

According to farmers, specific requirements for resistance or tolerance vary for crops and regions. However, the 2016 National Variety Catalogue for Mali has only a single column for one (undefined) combined score for resistance to diseases, insects and weeds.

Varieties' relative ability to produce on poorer or more fertile soils, their requirements for fertilizer use, their capacity to support late fertilization, to produce "for us poor people" or to grow on "our soil" were widely mentioned.

Varietal resistance or susceptibility to biotic constraints were also frequently mentioned criteria. Resistance to fungal and viral diseases were important in rice and pearl millet, tolerance to

Striga in sorghum and pearl millet and resistance to head miner in pearl millet. Particular resistances were indicated to be of major importance for varietal adoption in certain areas, like Rice Yellow Mottle Virus for irrigated rice in Niono, and head miner for pearl millet near Ségou. Furthermore, varieties' capacities to compete with weeds or to minimize bird damage were mentioned by some farmers. Varietal productivity, or yield, was mentioned across most interviews but was by no means described for all varieties when farmers were asked about advantages or disadvantages. Also, farmers almost never mentioned only yield as an important criterion; one farmer explained: "The choice of varieties is based on yield, but with other characteristics included".

Farmers' trust in their varieties and farmers' wanting to "maintain our varieties", even while growing and appreciating new varieties, were comments heard everywhere but most often and forcefully in Mopti. This trust was sometimes directly spoken of in terms of adaptation: "I trust my varieties. I will renew my seed from the village but not outside as I don't know if it is adapted".

Cases of complete losses were reported in some cases in relation to new varieties. One farmer harvested nothing from his 3 ha of rice sown with distributed seed that matured too late, and another had her field entirely eaten by the birds as the introduced variety matured before the other millet fields. One woman explained that she could not risk sowing an unknown variety as all she had was a 0.5 ha field.

ON-FARM PROCESSING AND USE

Diverse grain quality traits were widely used by farmers to indicate the advantages and disadvantages of the specific varieties they grow. These traits included varietal desirability for preparing local foods (e.g. *tô*, *degué*) and taste. Unacceptable grain quality can lead to rejection of varieties, as in the case of a farmer who grew a new sorghum variety called 'Grinkan', but when the women said the *tô* was not good, being too soft and not sticking together, he never planted it again. Farmers also mentioned grain aspects related to the yield of food,

"The deciding aspect is the consumption, even if a variety yields 20 t/ha, but cannot be eaten, it will not be acceptable."

A rice farmer

such as "gives much flour", and "heavy grain". Also, the mention of differences for grain storage (resisting insect attack in the granary) relates to amount of food obtained from the harvest of a given variety.

Varietal differences for ease of grain processing (decortication, grinding into flour) were mentioned, and not only by women. Furthermore, there was discussion of appropriateness of varieties

for particular grain uses such as the production of local beer (*Dolo*) and for fresh grain (corn roasted on the cob). Lastly, differences among varieties for the value of their stover (leaves and stems) for feeding ruminant livestock was mentioned for pearl millet and sorghum in Ségou and Koutiala-Sikasso regions. For farmers, the value of particular varieties was generally indicated to be based on the combination of traits for adaptation and use. For example, farmers from a women's cooperative spoke of the better drought and *Striga* tolerance, good

food quality for *tô*, heavy grain and acceptable stover when describing the sorghum hybrid 'Pablo' that is currently being adopted in their village.

MARKET DEMAND

The market for rice grain exhibits most differentiation for specific varieties, associated with clear price differences. The variety 'Gambiaka' was identified as the preferred rice variety by grain traders in Niono and Bamako, grain processors in Bamako, and consumers. The taste and the desirable long grain are preferred by customers. The purity of rice grain was a major criterion for marketing.

The yellow grained maize variety 'Sotubaka' was the one variety specifically named by grain traders, a grain mill (see box), and poultry feed processors. This variety was indicated to give good grits, flour and taste by grain

"We are here to produce" and "We need maize for the mill": Two short statements that capture the history of the Cooperative 'Wonkon' in Karangana, Koutiala region. Beginning in 1988, the parastatal cotton company CMDT established a grain mill in their village and provided maize seed as it introduced the maize crop in Mali. The farmer cooperative that provided grain to the mill became its owner when CMDT privatized. While struggling to supply the mill and produce the maize grits demanded in the market, the cooperative "found" the variety 'Sotubaka'. This variety had very hard grain and had high yield of grits, but no dependable seed supply in this remote village. Informed that saving seed from their fields year after year leads to lower yields, the cooperative decided to produce certified seed of 'Sotubaka' for its members. The cooperative continues to operate the mill, now producing grits as well as decorticated pearl millet and sorghum, marketed as far as Brazzaville, Congo and France, and thereby providing its members better prices for their grain. It now also produces hybrid sorghum seed, helping its members produce grain for the mill and for large volume grain purchases by the World Food Program as well as providing for home consumption.

traders. Certain poultry feed processors however identified white, red as well as yellow maize as having the desired quality. The purchase of grain was generally indicated to involve negotiation based on grain quality, price and demand.

Certain grain traders provide certified rice seed on credit to assure good quality and quantity of grain to the producer cooperatives from whom they purchase grain. A grain trader mentioned that low productivity levels on farm can cause significant difficulty for collecting the amounts of grain required; likewise, a grain miller said that ensuring sufficient supply was an important issue.

Sorghum and pearl millet are important grains in the cereal market, with large volumes being handled. These crops always have higher prices than maize. However, grain aggregators only spoke of quality in terms of cleanliness, e.g. the amount of sand and foreign material, and not of grain traits as such. Grain traders and grain processors in Bamako basically preferred sorghum and millet from certain regions, for example millet of Koutiala, and not of specific varieties or defined grain qualities.

Processing of grain of all four cereals into common food preparations (*tô*, *dégué*, *couscous* and others) and specialty foods for marketing pre-processed products in the city is done by women enterprises of varying size in Bamako. These are

relatively small enterprises, processing for example 100-300 kg of grain per day, but more for special orders and for the fasting month. Outside of Bamako, there appeared to be nearly no demand for this type of processed products, with one grain processor in Mopti actually being criticized by others for producing processed food products: *"There is labor force [women] at home who can do that work, and our women are not 'civil servants'"*. The only mention of varietal preferences by grain processors was for 'Gambiaka' rice.

5.3 WORKSHOP RESULTS: PRIORITY OPTIONS FOR SEED SYSTEM DEVELOPMENT IN MALI

The workshop in Mali was held with 25 participants and seven members of the study team, acting as facilitators and supporting the documentation of results. Out of the 25 participants, 18 were men and seven were women, with women participants representing either women farmer, seed producer or grain trading cooperatives, or (their own) private companies, e.g. seed company, agrodealer and grain processor.

The workshop started by presenting a synthesis of suggestions for seed system improvement proposed by seed system actors in the field interviews (described above in 5.2). These entailed options for improving infrastructure and equipment, financial and organizational support, strategic approaches, as well as options relating to improved information and access to seed.

5.3.1 WORKSHOP SESSION 1: OPTIONS FOR IMPROVING AVAILABILITY AND ADOPTION OF SEED OF IMPROVED VARIETIES (BY CROPS)

The first round of discussions were conducted by six groups of participants, with two groups each per crop/agroecology (rice, sorghum and maize, and pearl millet). Various actor types were present within each group. The task for one group per crop (groups 1 to 3) was to identify priority options for improving availability of quality seeds in proximity to farmers, whereas the other group (groups 4 to 6) considered options for enabling adoption of these varieties. The three highest-ranked options for the discussion groups 1 to 3 are presented in Table 10.

Table 10: Three highest-ranked options for improving the availability of seeds in proximity to farmers identified in each group discussion.

Crop/Agroecology	1 st preference	2 nd preference	3 rd preference
Group 1 (focusing on rice)	Availability of sufficient early generation seed	Stakeholder forum among seed cooperatives and partners for information diffusion	Identify needs to better plan seed production
Group 2 (focusing on sorghum and maize)	Produce seeds where they are needed	Increase the number of selling points	Build seed storage facilities
Group 3 (focusing on pearl millet)	Create seed shops near the areas of production	Create networks of seed producers	Improve capacities of agrodealers regarding the technical information for varieties to be selected for sale

Additional options identified included, for example, increasing the numbers of seed cooperatives and seed producers within and among villages, reducing the cost of seed certification, establishing demonstration plots for new varieties at publicly accessible sites, sign boards indicating locations where seeds are sold, and improving the recognition of value and benefits of local varieties regarding adaptation and productivity.

The three highest-ranked options for improving the adoption of improved seeds identified by groups 4 to 6 are presented in Table 11.

Table 11: Three highest-ranked options for enhancing adoption of improved seeds by farmers identified in each crop-based discussion group.

	1 st preference	2 nd preference	3 rd preference
Group 4 (focusing on rice)	Participatory plant breeding	Strengthen distribution networks / offer package sizes that are affordable for farmers	Involve the private sector for seed multiplication and selling
Group 5 (focusing on sorghum and maize)	Organize demonstration plots and farmer field schools	Participatory plant breeding	Organize visits to breeders' fields for seed sellers.
Group 6 (focusing on pearl millet)	Develop varieties with improved yield	Develop varieties with food quality (taste, storability, flour yield)	Develop varieties that are well adapted to the production zones (e.g. early maturing varieties)

Additional, but lower ranked, options of groups 4 and 5 were more or less similar to those mentioned earlier, with the need for demonstration plots being highlighted (see also box). Group 6, focusing on millet, emphasized that the major weakness in the pearl millet seed system was the absence of improved varieties for diffusion. For example, the wetter (over 1000 mm/a rainfall) pearl millet agroecology of Bougouni and Sikasso has no improved

pearl millet varieties, as breeding essentially focused only on the drier (600 mm annual rainfall) zone — even though certified seed of other crops is being produced in these areas. The participants of this particular group, therefore, discussed their priorities for traits that should be improved or addressed through plant breeding activities.

"It is the plant that attracts interest, not the seed as such."

(Workshop participant)

5.3.2 WORKSHOP SESSION 2: OPTIONS FOR ENSURING AND ENHANCING SEED QUALITY, BENEFITS FROM LOCAL VARIETIES AND COOPERATION AMONG SEED SYSTEM ACTORS

For this session, workshop participants discussed the above-mentioned issues in three groups; the results are shortly presented in the following sections.

OPTIONS FOR ENSURING AND ENHANCING SEED QUALITY

Women participants in this session insisted on having their own discussion group regarding options for ensuring seed quality, and thus this topic was discussed separately by one group consisting only of women and two groups of men. The other groups that discussed local varieties and cooperation among actors were dominated by male participants.

The options for ensuring seed quality emphasized by the first men's group focused on assuring full control and implementation of established regulations. This group indicated that state duties and legal provisions for seed inspection, control and certification should be fulfilled, and seed producer companies and cooperatives need to professionalize their activities accordingly. A further priority option mentioned was capacity building for seed producers with regard to seed production and storage.

The second men's group addressing the same topic suggested that transparent norms should be established for production and certification of quality seed, e.g. regarding the origin of early generation seed, the choice of the field and necessary requirements and measures to be taken during production, harvesting, threshing and storage, as well as for correct sampling, analysis and certification. They proposed a list of 'good practices' for seed

production and handling that ensure seed quality, based on their local knowledge and experience, and further suggested that certification should be organized in a decentralized manner, e.g. by establishing ‘micro-labs’ at local or regional level.

The women’s group proposed a detailed list of practical steps, based on their experiences, for producing high quality seed. They highlighted the importance of starting with a reliable, authentic seed-source, the choice of field, specific crop management practices, and precautions to be taken during harvesting, threshing and seed storage. They closed by stating that if all their advice is followed, farmers will have good seed, processors will have quality grain and consumers will be satisfied.

The women’s presentation of their propositions for assuring quality seed incited heated debate. The differences between supporters of legal, state-controlled seed quality procedures *versus* those supporting farmer-managed quality control based on practical experience and self-accountability was debated with such emotional intensity that the moderator struggled to simply close the discussion with an agreement that further interactions were needed on a topic of obvious concern and tension.

OPTIONS FOR IMPROVING COOPERATION AMONG ACTORS

The working groups focusing on options for establishing a stakeholder forum, and expected advantages, proposed that a broad range of actors should be involved, with the representative nature of participants being transparent. Participants could be, for example, seed producers, farmers, agrodealers as well as government actors, e.g. researchers and technical service providers. The forum was said to need clear regulations for meetings, with actors being formally involved and taking on responsibilities. The group further noted that even though such forums would be meant to facilitate dialogue, they need to be recognized by administrative bodies.

Possible issues to be addressed in stakeholder forums could be:

- Information exchange on availability of seeds
- Information exchange on availability of seed of particular varieties
- Strengthening capacity building of seed producers
- Improving seed sales
- Self-control of seed system actors, e.g. in cases where certificates are used improperly

The main advantages of such forums were expected to be improved availability of seeds and improved adoption by farmers, facilitation of seed commercialization, establishment of a communication network enhancing timely access to information for all involved, and finally improved food security.

“If people know each other, information spreads much more quickly.”

A workshop participant

The participants indicated that farmers and seed producers, seed sellers, grain traders, processors and researchers would all benefit from such forums, as well as other actor groups who are rather indirectly involved, e.g. the transport sector. Stakeholder forums were indicated to be required at various levels, e.g. national, regional,

at district and even community levels. It was also mentioned that separate groups could be formed for rainfed crops and for rice and other irrigated crops.

OPTIONS FOR IMPROVING BENEFITS FROM LOCAL VARIETIES

The working group on enhancing recognition of and benefits from local varieties proposed the following options:

- Prepare an inventory of local varieties for each agroecological zone of Mali
- Conduct interviews in order to find out why some varieties are abandoned

Results (Mali)

- Create a gene bank for local varieties
- Create a variety catalogue
- Create seed producer groups for seed production of local varieties, also including varieties that are of particular importance to women, such as 'Kendé' sorghum
- Create some sort of certification scheme for seed of local varieties
- Organize demonstration plots, field days and other events to improve recognition of the potentials of local varieties.
- Apply participatory plant breeding methods to overcome certain weaknesses of some local varieties

The group highlighted the importance of ensuring women's participation in such activities, since there are local varieties that are exclusively grown by women. Furthermore, it came out in the discussion that the Genetic Resources Unit of IER maintains a collection of local varieties and a catalogue of the stored varieties, which was, however, not available to the general public. The participants suggested that such information could be published on the internet site of IER.

5.3.3 WORKSHOP SESSION 3: PRIORITIZED OPTIONS FOR SUSTAINABLE SEED SECTOR DEVELOPMENT IN MALI

In the final session, workshop participants scored options proposed in the previous sessions to identify specific options of highest priority. The results are presented in Figure 10.

Initiating stakeholder forums as well as enhancing capacities of seed-producer cooperatives and agrodealers were seen as top priorities for supporting sustainable seed system development. Stakeholder forums were suggested to be initiated at different levels, or involving different actor groups. The main purpose of such forums would be improved coordination and targeting of activities towards other actors' needs.

Capacity building for seed-producer cooperatives could involve technical as well as financial and operational capacities; for agrodealers, improved knowledge of varieties as well as communication, marketing and networking capacities were regarded as a priorities by the workshop participants.

GOVERNMENT ACTION AND FREE DISTRIBUTION OF SEED

The workshop participants further discussed and assessed government actions for strengthening seed systems and the issue of free seed distributions.

The group generally agreed that the government should strengthen and subsidize seed certification schemes. However, most workshop participants indicated that the distribution of free seed was poorly done and not sustainable. They said it was poorly targeted, lacked a clear objective and was not organized appropriately, and that the quality of seed distributed was poor. Although a few noted that direct seed distribution could help some farmers, most participants clearly rejected this option, noting that free seed distribution *would "kill the seed system"* and was *"a setback for those who produce good seeds"*.

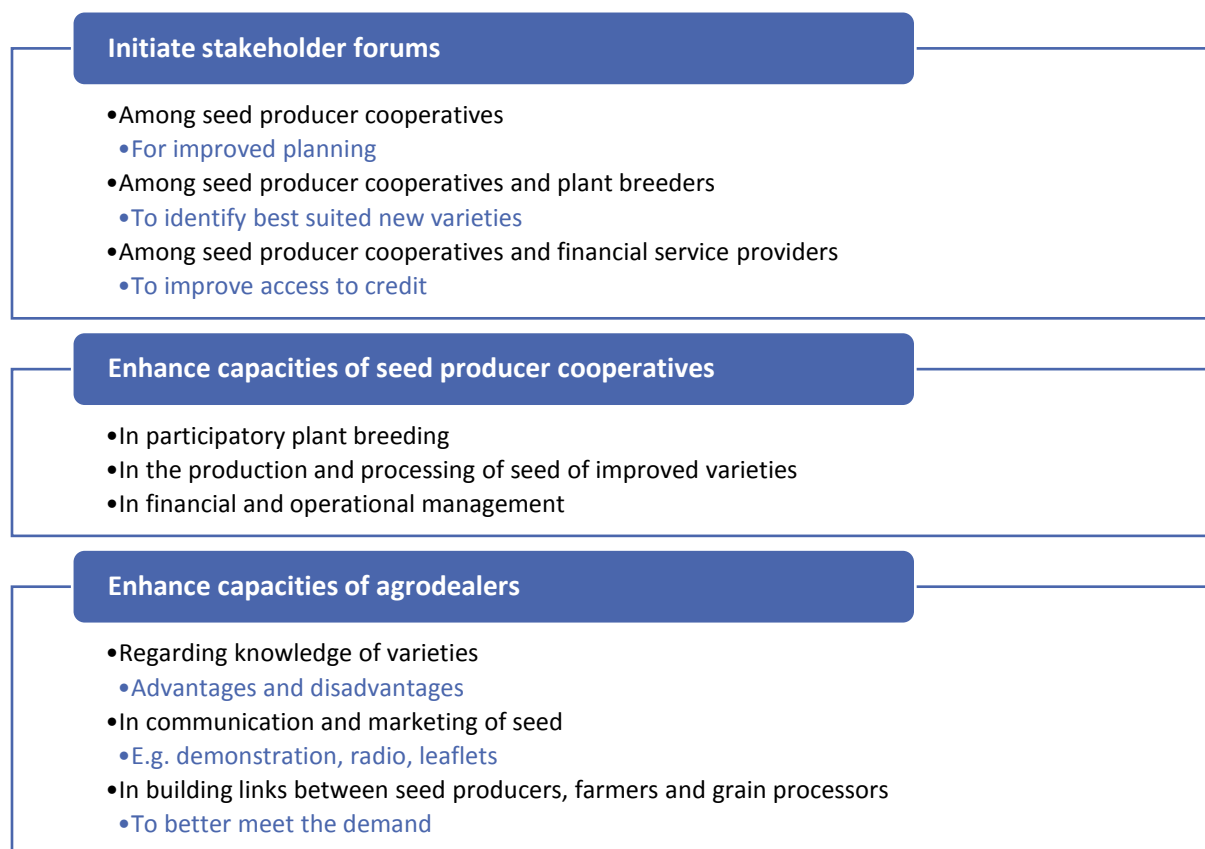


Figure 10: Options for sustainable seed system development in Mali in order of preference (from top to bottom), prioritized across all workshop participants.

6 DISCUSSION OF RESULTS

This study seeks to identify pathways, promising models and options useful in establishing an agenda for dynamic and sustainable seed system development for staple cereals in two contrasting countries, Kenya and Mali, based on the actors' own experiences and insights (see Chapter 2).

The extensive findings of our study, presented in Chapters 4 and 5 for Kenya and Mali, respectively, are discussed and synthesized into major issues where improvements are desired and necessary for the system to better meet the various actors' needs. The discussion of these issues is organized here by the three aspects of seed system security — seed quality, seed availability and access to seed, which were introduced in Section 3.1. This discussion is presented in Sections 6.1-6.3, followed by a discussion of cross-cutting issues (Section 6.4).

These issues, and their corresponding opportunities for change and innovation, emerge primarily from the experiences and visions of the diverse actors; however, the discussion is extended based on the study team members' experience in seed system innovation and published literature.

The diverse issues brought out in this discussion point to actionable elements for addressing the challenges of 'making that last mile' to reach small-scale farmers and facilitate joint learning and action to achieve common goals. More detailed action opportunities, addressing specific crop and country contexts, can be elaborated from these synthesized findings and are presented in Annex E. Ideally, the actors directly concerned would be involved in defining these actions in detail, thus enabling ownership, completeness, and depth.

The discussion chapter concludes with a reflection of the approach and methodology used and the quality of results achieved (Section 6.5).

6.1 SEED QUALITY

The *'raison d'être'* of any seed system is provision of seed of value to the user, as indicated by modern seed systems using terms such as 'improved seed' or 'quality seed'. Modern seed systems, to be viable, have to provide benefits and options valued by farmers and not met with their own seed and seed management systems. We therefore take the *seed quality* element of seed system security as the first entry point for discussing the study findings and implications for sustainable seed system development.

6.1.1 VARIETAL ATTRIBUTES

The two types of varietal attributes that appear most responsible for mismatching between farmers' demands and variety supply were (a) the quality of grain for food use, and (b) adaptation to farmers' conditions, including low-input conditions. These issues arise firstly from the fact that home consumption is a priority goal for smallholder farmers in Kenya and Mali. For example, of all farmers in Kenya who sowed maize in 2010, only 28% sold maize (Smale and Olwande, 2014). Secondly, it is without question that smallholder farmers, men and even more so women, suffer low yields due to poor soil fertility. Furthermore it is expected that resource-poor farmers are most vulnerable to climate variability, with low soil fertility amplifying yield losses due to aberrant rainfall patterns. New varieties that grow better under low soil fertility conditions could offer more yield stability, while also reducing additional financial risks that may be associated with the use of purchased chemical fertilizers under these conditions. Adapted hybrids, with advantages of hybrid vigor, could help provide resilience and yield advantages over a range of stress conditions (Rattunde *et al.*, 2013; Kante *et al.*, 2017) depending on the parental material used.

The quality of maize grain for food was found to be a key varietal attribute farmers consider when choosing their maize variety in Kenya (Section 4.2.5), with farmers showing reluctance to switch from an old hybrid to newer hybrids with less desirable grain quality (Smale and Olwande, 2014). Yet, little or no mention was made of grain quality by breeders or seed company representatives (Section 4.2.2). The breeding of new varieties with good

grain quality is certainly feasible, with abundant genetic variation for good quality. For example, the local varieties that farmers cultivate and appreciate could be a prime source. This is exactly the approach reported by a Malian national sorghum breeder who reported changing their programs' breeding objectives to give greater emphasis to use of local germplasm to assure acceptable grain quality (Section 5.2.5). The context for this change: the breeders' involvement in farmer participatory variety testing (Section 5.2.2) and incidences of farmers trying but abandoning new sorghum varieties due to unacceptable grain quality (Section 5.2.5).

For a smallholder farmer, the adaptation of a newly developed variety, as expressed through its yield and yield stability under the farmers' own production conditions, will determine whether it is a worthwhile option for her or him. Adaptation to low soil fertility is a key aspect that is desired/demanded by these smallholder cereal farmers in both Kenya (Section 4.2.5) and Mali (Section 5.2.5), but appears to be overlooked by some breeders and seed enterprises when proposing new varieties. One factor that may contribute to this situation for maize in Kenya is the origin of the maize seed industry, with KSC being established by and for the European settlers in the colonial period (Smale and Olwande, 2014), and the question of sufficient reorientation of breeding objectives since then to address resource-poor farmers' needs. Development donors can play an important role in orienting priorities of future research towards meeting smallholder farmers' (including women farmers') needs, since breeding programs are highly dependent on project funding (Sections 4.2.2 and 5.2.2).

Clearly, new varieties can be developed that perform better than current bred and local varieties under smallholder farmers' conditions. Although adaptation is complex and requires long-term research, progress for improving adaptation to low soil fertility is achievable with appropriate breeding materials and selection under conditions close to those of the farmers (Bänzinger and Cooper, 2001; Leiser *et al.*, 2012; Mueller and Vyn, 2016; Gemenet *et al.*, 2016). Continuing and strengthening collaboration between breeders and farmers (the key to being more effective according to one national breeder, see Section 5.2.2) is vital to create and identify varieties meeting smallholder farmers' needs. Conducting larger-scale progeny and yield testing in on-farm trials is possible and needs to be pursued to make greater genetic gains for performance under farmers conditions (Rattunde *et al.*, 2016). Farmers, and particularly women farmers, can assist and complement breeders' efforts to identify varieties with better food quality (Christinck and Weltzien, 2013), and an array of tools for effective researcher-farmer collaboration are available for such applied research (Christinck *et al.*, 2005).

6.1.2 VARIETAL DIVERSITY

The issue of varietal diversity is discussed here with regard to the importance of varietal diversity for farmers and for sustaining commercial seed systems, as well as in view of implications for varietal creation and delivery and possibilities for increasing varietal diversity in Kenyan and Malian contexts.

IMPORTANCE OF VARIETAL DIVERSITY FOR FARMERS

Farmers interviewed in Kenya and Mali reported growing several different varieties of the same cereal crop. Farmers also reported cultivating both bred and local varieties; e.g., millet producers in Mali and maize producers in Kenya. Use of varietal diversity to meet different production objectives, to minimize risk and maximize productivity in the context of diverse production conditions is recognized as an important strategy for smallholder farmers (Rooney, 2004). Ten to 25 or more varieties of sorghum are cultivated as distinct pure stands in just a single village in Mali (Siart, 2008) or Burkina Faso (Barro-Kondombo *et al.*, 2008).

Furthermore, varieties with novel traits can offer farmers new options for producing or using their crops. Examples include earlier maturing varieties enabling relay cropping (e.g. reported by women maize producers in Kenya (Section 4.2.5)) or capturing higher grain prices prior to the general harvest (e.g. sorghum in Mali); or novel dual- and multi-purpose sorghum varieties (Section 5.2.2) for production of higher quality fodder and/or sorghum syrup as well as grain for food. Varietal diversity can thus both promote dynamic production systems as well as

help farmers respond to changing conditions, including changes due to climate variability (Hausmann *et al.*, 2012).

IMPORTANCE OF VARIETAL DIVERSITY FOR SUSTAINING COMMERCIAL SEED SYSTEMS

The provision of new varieties, offering new options to farmers, underpins sustained commercial seed systems. Especially in the context of seed systems using primarily OPV's, new further improved, diversified varietal options are essential to maintain customers' interests to purchase seed. Similarly, in commercial seed systems focusing on hybrids, business opportunities are linked to the varietal diversity on offer, the capacity to innovate, often linked to the skills of predicting future varietal needs, based on detailed insights about the development of production systems, specific markets or new opportunities. The capacity to create and disseminate new varietal diversity is essential for dynamic seed system development.

CREATION AND DELIVERY OF VARIETAL DIVERSITY

Taking a 'big picture' view of the seed systems for staple cereals in Kenya and Mali, it becomes clear that farmers contribute in a major way to varietal diversity. The over 1000 sorghum landrace varieties collected in Mali, for example, and the farmers' continued success in provisioning and using of landrace varieties bears witness to their skill and capacity with seed-related activities.

Public breeders also are major players on the larger scene for variety creation in Kenya and Mali, where science-based breeding programs are conducted only or predominantly by public institutions (Sections 4.2.2 and 5.2.2). Although private company investment in maize breeding exists in Kenya, it is comparatively rare.

POSSIBILITIES FOR INCREASING VARIETAL DIVERSITY IN KENYAN AND MALIAN CONTEXTS

Initiating or increasing private company breeding requires examination of (a) the economic feasibility based on the potential market size (crop areas sown, potential seed revenues) relative to the cost for each specific agro-ecological zone where separate breeding programs are required (Section 6.2.2) and the diversity of the variety portfolio that they could provide. Potential collaboration between public and private breeding, and between public breeders and farmer seed-producer networks, warrant attention and are considered in Section 6.2.2. Likewise, regulatory and control options that speed availability of new varieties (Section 6.2.2) would also contribute to increasing varietal diversity.

Finding ways to raise the current low investment in breeding (Sections 4.2.2 and 5.2.2), in relationship to the diverse opportunities and needs, would certainly help increase varietal diversity in Mali and Kenya. Recognizing the vital role of variety creation and varietal diversity both to seed system functioning and to climate change mitigation should enable targeting some of the substantial aid and development investments for seed activities (Sections 4.1.4 and 5.1.4) and for climate change mitigation towards breeding new varieties meeting also small-holder farmers' needs. To address these issues, new instruments for financing sustainable seed system development should be taken into account to facilitate the level of varietal diversity which is available to farmers (see Section 6.2.2).

6.1.3 SEED GERMINATION, PURITY AND COUNTERFEIT

Government agencies are rejecting seed lots based on established criteria for seed quality in both Kenya (Section 4.1.2) and Mali (Section 5.1.2). It thus seems that these regulations and controls contribute to reducing the frequency of commercially traded seed with low germination and off-type plants.

The occurrence of poor seed germination was, however, an issue in Kenya (Section 4.2.3 and Box), both for certified and farmers' own seed, whereas it was not an issue of concern for either type of seed in Mali (Section 5.2.3). Furthermore, 'fake seed' was an issue in the Kenya seed market (Section 4.2.3; Karingu and Ngugi, 2013) and KEPHIS is undertaking anti-counterfeit measures (Section 4.2.3), whereas there were no reports of fake seed

in the Malian commercial seed market, although serious cases were reported for direct seed distribution (Section 5.2.3).

These results were surprising since Kenya has such an elaborate regulatory system and highly professional control agency, yet the seed control system in Mali is far weaker in comparison. This paradox strongly suggests that factors other than the legal control system need to be examined for their role in impacting good seed germination and trueness to type.

One factor contributing to this paradox may be the extent to which the farmer knows the person providing the seed and the origin of the seed. Something that suggests this is that seed purchases in Mali were most frequently made between farmers and seed producers and sellers who knew each other, whereas that seems to be less the case in Kenya. Admittedly, the relatively lower frequency of seed purchases in Mali results in a smaller sample size, and thus substantiation is needed.

Another aspect that warrants examination is that of socio-cultural norms and cultural seed knowledge and its impact on physical and physiological quality of seed. In fact, the traditional cultural norms regarding seed for the staple cereals are still quite strong in Mali (Section 5.2.4), but seem to have considerably weakened in Kenya, such that this issue also warrants examination.

The analyses of seed quality of Malian farmers' own saved seed that are known have shown that, indeed, Malian farmers are skilled at producing and maintaining seed with good germination capacity (Diallo, 2009) and genetic purity (Deu *et al.*, 2014). The depth of farmers' knowledge and skills regarding seed quality, including attention to practical aspects not considered in formal seed quality control, was exemplified in the presentation made by the women seed producers working group on options for enhancing seed quality in the Mali workshop (Section 5.3.2). Therefore, the questions raised include: How can these farmers' skills and practices of self-control of seed quality be maintained, and how can they contribute to effective and less costly control of seed quality in the future?

Recent analyses of germination rates of the popular hybrid H614D in Western Kenya (purchased through 'covered shopping' at 167 seed shops covering roughly 75% of the registered shops in each of four study areas) found considerable numbers of hybrid purchases with germination rates below 50% across all shop sizes. The average germination rate was found to be only 77%, instead of the 95% required for certified seed. Poor germination of hybrid seed was concluded to impose high costs on farmers, to increase risk of losses, including of associated inputs, and to discourage adoption.

Tjernström et al. (2017)

Another hypothesis of what contributes to differences in seed germination capacity in Kenya and Mali is the details of the seed dissemination pathway. Certified seed in Mali is generally not treated (and if so, just before sale) and seed that remains unsold after the season is sold on the grain market; whereas in Kenya, seed is treated and unsold seed is carried over for sale in the following season, with risks of deterioration under suboptimal storage conditions. Another difference is that the delivery chains in Kenya are typically long, with multiple transactions between seed companies, distributors and retailers, whereas in Mali, there are few transactions between the farmer cooperative that produced the seed and the farmer obtaining the seed. Another difference is that the liability of unsold seed in Mali is entirely born by the cooperative that produced the seed, whereas in Kenya the liability is carried by the seed seller (distributor or agrovet) who last purchased the seed.

duced the seed, whereas in Kenya the liability is carried by the seed seller (distributor or agrovet) who last purchased the seed.

These differences, and their potential consequences for risks of deterioration of seed viability, suggest exploring options for (a) treating seed closer to the time of sale, and (b) more decentralized seed production and distribution systems with shorter delivery chains.

Although fake seed obviously results from individual people or businesses taking advantages of opportunities to cheat for selfish gains, combatting it apparently has been restricted to control options which have costs but little addition of value. An interesting alternative response would be to explore ways of investing in strengthening relationships between seed sellers and buyers, including personal and socially valued relationships with creation of trust (Section 6.1.4) and tap the power of reputation that could reduce fraud and yield additional benefits.

6.1.4 QUALITY OF SEED AND TRUST

Farmers' personal knowledge of and trust in the people providing seed seemed to be an important and powerful factor for the success of many seed enterprises. The very diverse cases that we encountered that exemplified this included a seed seller in Kenya engaged with diverse farmer social groups (Section 4.2.4), and in Mali an individual farmer producing seed of irrigated rice varieties, a women's seed-cooperative producing submerged-rice seed, and a farmers' association marketing pearl millet seed in the driest (and insecure) north of the country — all of whom had a stream of farmers coming to them to buy their seed, mainly farmers from the area who knew and trusted the provider.

A counter example would be a farmer's comment that he would never buy seed "from Bamako" (the distant capital city where seed companies are clustered). Adaptation is a key issue underlying smallholder farmer's trust in their own varieties and their reluctances to use seed from 'outside', and particularly for the less favorable production areas in Mali (Section 5.2.5) and in Homabay or Tharaka Nithi Counties in Kenya (Mucioki *et al.*, 2016c).

Trust is vital for all business transactions; for seed transactions, it is a particularly 'sensitive' issue for various reasons. The risk of loss, even catastrophic crop failure, from using an unadapted variety is one aspect, particularly for smallholder farmers. Social norms and values maybe another, with acceptable practices for acquiring and selling seed likely arising from the complexity of seed and farmer's requirements of varieties with the traits needed for the survival and well-being of their families and communities. Therefore, considering trust between seed providers and farmers, and options that strengthen it, will be vital for developing effective and sustainable seed system development options that are adapted to agroecological as well as socio-cultural contexts.

6.2 SEED AVAILABILITY AT THE RIGHT TIME AND PLACE

The availability of seed of desired varieties at the right time and place, and client knowledge of where this seed is available are critical for an effectively functioning and sustainable seed system. In contrast, hindrances to availability of seed of desired, well-performing varieties, in a timely manner cause economic and productivity losses and discourage reliance on that particular seed channel.

6.2.1 REGULATORY CONTEXT

The regulatory context is understood here by socio-cultural as well as legal norms, both of which influence the availability of seed to farmers, as explained below.

SOCIO-CULTURAL NORMS

Socio-cultural norms regarding seed handling and acquisition can be important determinants of seed availability for smallholder farmers. Seed systems of traditional cereal crops, such as pearl millet, sorghum and rice for rain-fed and submerged production systems, are strongly influenced by such norms in Mali (Section 5.2.4; Coulibaly *et al.*, 2014). The socially acceptable ways of obtaining seed, perceptions about and trust in seed from 'inside' the social system and from providers who are personally known are important examples. These norms ensure

that seed remains available, even following severe disasters, such as drought conditions (McGuire and Sperling, 2016; Siart, 2008).

Approaches that are considerate of such norms are showing benefits for contributing to availability of new varieties. For example, ‘socially compliant’ seed dissemination with local sales points, local farmers’ engagement in variety development, and locally acceptable modes of selling seed have enhanced availability of new varieties in Mali. For OPV varieties of rice or sorghum, these approaches have led to new varieties entering into local dissemination systems (Sections 5.2.3 and 5.2.4). Studies in Mali similarly found consideration of cultural norms of importance for initiating integration of new varieties into local systems (Siart, 2008), enhancing local availability (Deu *et al.*, 2014) and adoption of new varieties (Smale *et al.*, 2016). Although in Kenya the social norms relating to seed have weakened (section 4.2.4), seed proximity and timeliness of seed availability, coupled with issues of trust (section 6.1.4) are just as vital to farmers’ seed acquisition decisions as in Mali. Hence, consideration of cultural norms regarding seed and variety issues is critical for the design and development of effective seed dissemination initiatives.

LEGAL REGULATORY NORMS AND PRACTICE

The official registration and release of varieties controls which varieties can or cannot be made available in commercial seed systems. Currently, landrace varieties of maize and sorghum are basically not released in Kenya or Mali, which blocks availability of these varieties through commercial channels, something that smallholder men and especially women farmers wanted (Sections 4.2.5 and 5.2.5). Discussions and exploration of ways to include other types of varieties in commercial seed systems would be useful to increase the varietal diversity that is made available to farmers (see Section 6.1.2). Furthermore, examination is needed of how the release process can be structured to best serve the Malian and Kenyan needs and context, rather than reproducing a process developed in the context of other countries. A case worthy of examination is the earlier system in Mali, which emphasized documenting the characteristics, origin and entities responsible for breeders’ seed (section 5.2.2), in comparison with the regulatory framework that Mali is attempting to put in place that is based on a manual originally elaborated in the USA (Section 5.1.2).

Seed certification procedures causing delays of seed becoming available for dissemination in Kenya were mentioned by seed companies (Section 4.2.1) and a seed study review (Context Network, 2016), and in Mali by seed-producer cooperatives and government agents (Section 5.2.1). To reduce these delays, actors in both countries suggested that seed certification services could be decentralized, more self-certification facilitated, as is presently being tested in Kenya. Alternative legal seed regulations and pathways to speed availability of new varieties and commercial availability of local varieties was an overall top priority identified in the workshop with seed system actors in Kenya (Section 4.3.3). Quality Declared Seed (QDS; see box on next page) was identified as a strategy for improving availability of quality seed for farmers during the 1980s (FAO, 2006). Such a system could help resolve the constraint of limited availability of seed of landrace varieties (Section 4.2.1 and Mucioki *et al.*, 2016b), without having to rely on “*deviant informal local institutions*” (Mucioki *et al.*, 2016c). Furthermore, it could help decentralize seed quality control and reduce costs for seed certification and thus cost of seed, while increasing overall availability of seed of varieties chosen by local producers and seed traders based on local demands (Section 6.1). Such a system could also encourage local initiatives in the breeding and seed sector. The development of India’s private seed industry would not have been possible without the provision of a QDS type system (Pray *et al.*, 1991; Pray and Ramaswami, 2001). A QDS type system appears to match farmers’ experiences and expectations for traditional staple cereals, with responsibility for seed quality born by those who produce and provide seed, and thus could be as effective in facilitating seed system development in Kenya and Mali as it was in India. A functioning justice system is also seen as helpful for building trust in and among actors in this type of regulatory context.

Quality declared seed (QDS) places the responsibility for quality control on the seed producer and seed trader, with the government seed quality control agency conducting periodic checks, of approximately 10% of the seed lots. In most QDS schemes, seed producers and seed traders need to be certified, in terms of facilities, knowledge and skills. QDS tends to be applied only to certain crops and varieties, often those for which profit margins are low, including for facilitating the sale of seed of specific local varieties (FAO 2006).

Stakeholder forums, involving concerned actors, including farmers representing also the interests of smallholder and especially women farmers, are critical to explore and/or extend the existing legal frameworks and regulatory system for improving seed availability of variety innovations in a dynamic, demand-driven manner. This is especially critical in the context of climate change and emerging challenges, such as the ‘fall armyworm’ outbreak across Africa, that require more nimble responses. Regulatory systems that provide space for a diversity of approaches for collaboration between private and public sectors for variety development, release and seed production are expected to have a better chance

to meet the enormously diverse needs of smallholder cereal farmers in countries like Kenya or Mali, with such a wide range of agroecological conditions and production systems, compared to systems that focus on a narrow range of actors and variety types.

6.2.2 COLLABORATION BETWEEN SEED SYSTEM ACTORS TO IMPROVE AVAILABILITY OF NEW VARIETIES

Ample potential exists in Kenya and Mali for improving availability of seed of new varieties by enhancing collaboration between different seed system actors. Options or models for such collaborations, including public-private collaboration and innovative funding models, are presented below, based on observations of the current context.

OBSERVATIONS OF CURRENT CONTEXT

Availability of seed of new varieties to farmers is highly or entirely dependent on collaboration between public and private sector actors in both Mali and Kenya. Although it is indisputable that such collaboration is delivering seed to both countries’ farmers, the turnover of staple cereal varieties in both countries is slow. Maize varieties cultivated in Kenya, for example, are currently estimated to have a mean ‘age’ of 17.6 years (Smale and Olwande, 2014; see also Section 4.1.3). The existence of contentious public-private negotiations regarding maize hybrid licensing in Kenya (Section 4.2.3) and the constraints on variety development due to funding levels and dependence on short-term project grants (Sections 4.2.2 and 5.2.2) are seen by breeders in both countries as hindering availability of new varieties. At the same time, private sector investment in variety development is currently limited to just a few crops and target ecologies, for which sufficient returns on investment can be expected. Therefore, examination of models for effective public-private collaboration and innovative funding models, even for small and specific markets, should be a priority for seed system development in both countries.

MODELS FOR CONSTRUCTIVE PUBLIC-PRIVATE COLLABORATION AND FUNDING OPTIONS

Constructive public-private collaboration can create synergies, e.g. based on complementary resources, networks and capacities, or different options to access and mobilize funds. Besides these practical advantages, collaboration across actor categories (see Figure 6) in general has the potential to raise the ability of seed system actors to set joint priorities, identify and address conflicting issues, and to work more effectively towards collectively identified goals (Weltzien and Christinck, 2009).

A historical model of the public sector building and harnessing emerging private-sector seed companies developed in southern Germany, in the context of public plant breeders who were poorly resourced and challenged by high agroecological diversity (Harwood, 2012). These public agents established and worked with so-called ‘farmer-breeder clubs’ for variety development, seed production and dissemination, in what Harwood describes

as ‘peasant-friendly plant breeding’. Linkages with grain-producer marketing cooperatives were critical for facilitating uptake of the new varieties. Benefits accrued to the users of the new varieties through increased yields and improved prices for specific grain qualities.

The currently evolving collaboration in Mali between public plant breeders and farmer-managed seed enterprises, mostly cooperatives focusing on irrigated rice, sorghum and pearl millet (Section 5.2.2), shares many elements with the above-described historical model from southern Germany. The potential this model offers for staple cereal breeding in Mali and in Kenya, and opportunities for its further upscaling and sustainability, warrant examination. Social and economic case studies of efficiencies, constraints, and sustainability of existing examples, and identification of demands for capacity building, jointly with involved breeders and farmer cooperatives, would give guidance for future development.

The ‘Hybrid Parent Research Consortium’ developed by ICRISAT in India for pearl millet and sorghum improvement⁴⁹ represents another mode of collaboration between public breeding institutions and private companies. Private seed companies join the research consortium for a fixed period, pay annual membership fees, and gain access to breeding material during all stages of parental line development, under the conditions of the Standard Material Transfer Agreement (SMTA) as demanded by the ITPGRFA. The consortium members can also exert influence on the breeding priorities of the ICRISAT-managed breeding programs. This model requires that private sector companies have a minimum of variety development capacity (e.g. at least making and testing new hybrids) which is emerging in Kenya but not yet in Mali. The breeding materials thus remain in the public domain as global public goods and a substantial part of the basic operational costs for the public breeding program are covered by private sector contributions, while the private sector invests in the final stages of adaptive research for hybrid identification.

An approach to public-private collaboration that is currently active in Germany is the creation of an association of private seed companies that identify priority needs for research, and then offer competitive research grants to public institutions with association funds. This model facilitates small- and medium-scale companies to contribute to setting public research priorities and to benefit from new technologies and insights ‘as they evolve’ and thus remain competitive despite less in-house research capacity⁵⁰. This model requires that companies can effectively use research results and deliver them to farmers, as well as a legal framework and procedures for the functioning and monitoring of such an association, best within the context of a functioning justice system. Furthermore, this association, by partnering with national and European public agencies, can attract additional research funds. The research results remain in the public domain, accessible to all members, and the general public, while separate patent and variety protection rights are distributed, based on agreed procedures.

A further example is that of crop growers associations in USA funding public crop research focusing on priorities identified by the associations. The funds are collected by a ‘checkoff’ organization from producers of a particular agricultural commodity and used to promote and do research pertaining to the commodity. Dues are collected during normal transactions in the supply chains, e.g. selling of grain. The United Sorghum Checkoff Program is one example; here, the checkoff is collected from the ‘first handler’, i.e. the person who first buys a defined quantity of grain or fodder from an agricultural producer.

Finally, a national fund for crop development is presently being discussed in some countries, based on the understanding that not only farmers and/or value-chain actors benefit from breeding activities that increase the multiple values of crops, but society as a whole. Furthermore, by collecting voluntary contributions not from farmers or ‘first handlers’, but rather from actors at the ‘upper’ end of the chain, e.g. food processing companies

⁴⁹ For more information, see <http://www.icrisat.org/pearl-millet/> (22 November 2017)

⁵⁰ For more information, see http://www.bdp-online.de/de/GFPi/Ueber_uns/ (22 November 2017)

and retail traders, the share of the product value that is required to raise the same amount of funds can be reduced (Kunz *et al.*, 2015). Governments and international donors could also contribute to such funds. Ideally, a committee of societal stakeholders, including representatives of various groups of farmers, value-chain actors and civil society, would guide fund allocations to ensure that value is created towards commonly defined goals, including for example environmental, nutritional or health benefits. Any breeding organization, public or private, could apply for their breeding projects to be funded, provided that they serve the agreed-upon goals.

These few examples show that stakeholder interactions as well as the development of organizations of professionals, including farmers, are critical for the development of both private as well as public sector capacities and simultaneously creating opportunities for contributions to variety development that have a potential to overcome the currently observed limitations. A wide array of options exist, from public sector breeders 'nurturing' emerging seed companies, to farmer and crop growers raising their own funds for demand-driven public research. Particularly in view of rapidly changing agroecological production conditions, climate change, and socio-economic transformations, such models of collaboration could enhance the dynamics and innovation capacity of seed systems (Section 3.1.6), making more and better varieties available to farmers and increasing the level of domestic varietal diversity (Section 6.1.2).

We expect that national stakeholder forums in both countries would find analyses of learning and experiences from 'outside' and the past to be useful in their deliberations. Furthermore, the potential of improved collaboration between actors for reducing transaction costs could be a matter of shared interest and deserves further study. Increasing awareness of the 'public-sector builds private-sector capacity' model by actors and institutions interested in targeting the poorest farmers, including women and men working under difficult agro-ecological conditions, could help produce innovative solutions to the common problem that these farmers, even though defined as a 'target group', are often not adequately served by standard breeding and seed system development approaches.

6.2.3 DIVERSE MODELS FOR SEED DISSEMINATION

Improving the seed dissemination of improved varieties to the millions of mostly smallholder farmers in countries like Kenya or Mali, with diverse and changing variety needs, is the defining challenge for sustainable seed system development. Hence, we discuss below options for seed delivery channels that respond to this challenge; since the contexts in Mali and Kenya are so different, we discuss options for improving seed availability for their farmers separately, and then compare the situation in both countries, based on a range of business models encountered.

SEED DISSEMINATION IN KENYA

The following points summarize the current situation for seed provision in Kenya based on the results presented in Sections 4.1 to 4.3). The emphasis of this summary is on aspects of importance for availability of improved seed for small-scale farmers, including women and men:

- Limited early generation seed quantities do appear to impact availability of certified seed, at least of specific hybrids under high demand.
- The availability of older successful inbred lines is threatened, because they are not routinely entered into the national genebank.
- Seed production capacity seems sufficient to meet seed needs generally, but can be jeopardized by disease outbreaks, such as MLN.
- Some companies are increasing their number of conditioning facilities and thus moving into major areas targeted for seed sale, e.g. SeedCo opening a new facility near Kitale, in Trans Nzoia, where demand for hybrid seed is very high.
- There is a dense network of agrodealers engaged in seed sales where maize breeding (especially hybrid breeding) has been successful, and improved seed is thus readily available to most farmers, e.g. in Trans Nzoia County.

- Availability of preferred varieties was the main seed-availability concern in areas with high agrodealer density, and concerned both commercial hybrids and specific local varieties, especially for small-scale farmers, including women farmers (Section 4.2.4).
- Low density of agro-dealers, and poor availability of improved varieties and of commercial certified maize and sorghum seed occurs in less favorable production areas (Section 4.2.5), e.g. Tharaka Nithi County.
- Grain traders contribute to availability of seed of improved varieties, including certified and un-certified seed, in less favorable production areas (Sperling *et al.*, 2008; FAO, 2014; Mucioki *et al.*, 2016b,c).
- Less favorable production areas, like Tharaka Nithi County for example, regularly receive free seed distributions (over the past 10-20 years often via local government offices), thus discouraging development of local capacities for sustainable commercial provision of improved seed to more remote farmers.

Agrovets do provide a network of seed sellers in Kenya, and thousands have received training to help improve seed availability. Yet, issues such as geographic areas with low-density coverage (e.g. Tharaka Nithi), poorly-informed vendors behind the counter, and lower-value (and interest) of seed relative to other higher-value merchandise call for continued improvements and exploring additional pathways. An alternative way of disseminating seed is promoted by FIPS-Africa (an NGO). The FIPS model is based on engagement of younger farmers with good social and communication skills as change agents (Section 4.2.4). Another approach, also with community focus, is that of farmer groups producing and disseminating locally preferred varieties, and receiving some support for building local seed-production and dissemination capacity (Section 4.2.4).

Grain traders also operate as seed sellers (Section 4.2.4) and could offer a major dissemination path. Grain traders in Kenya may have certain advantages over agrovets as seed providers, as they tend to have detailed knowledge of the grains, qualities and production areas where they work, often being farmers themselves. They may be able to provide more reliable information about varietal options than vendors who focus on veterinary and other products most of the year. Despite the many free seed distributions, farmers still obtained seed from grain traders in their local markets (FAO, 2014; Mucioki *et al.*, 2016b,c). The possibilities for seed companies and distributors to collaborate with grain traders to improve seed availability for smallholder farmers seem worth exploring. This approach has been examined in some countries for bean seed (Sperling *et al.*, 2008) and appears to warrant study for maize and sorghum in Kenya.

The diversity of issues relating to availability of preferred varieties indicates the need for whole-system engagements beyond density of sales points. One priority issue identified by the national workshop participants was improving information exchange and capacity for the concerned actors involved in seed distribution to more swiftly provide seed of varieties demanded by farmers, also by smallholder farmers (Section 4.3). Better knowledge of advantages and disadvantages of specific varieties, for example, will help seed sellers offer appropriate varieties. Cash-flow constraints, especially for seed sellers, contribute to limited varietal choice and to delayed availability (Section 4.2.4). Furthermore, small-scale farmers, who often buy seed 'at the last minute', suffer most from limited varietal choice, since poorly adapted or unknown varieties tend to increase production risks. Yet, another factor limiting seed availability and choice appears to be commercial marketing practices such as inducing stockists to not carry seed from other companies, or withholding more preferred varieties to facilitate sale of less preferred ones first (Section 4.2.4). Therefore, discussion and study of how different seed system actors can better collaborate for achieving common goals is clearly needed for improving seed availability, particularly for smallholder farmers.

SEED DISSEMINATION IN MALI

The current situation for seed provision in Mali can be summarized as follows based on results obtained for the four staple cereal crops studied (Sections 5.1 to 5.3). The focus here is on certified seed, as early generation seed was only rarely mentioned as a constraint. Noteworthy points include:

- Certified seed for all four cereals is mostly produced by farmer cooperatives or small Malian group businesses (Section 5.2.3). This certified seed is physically available over increasing sites and areas, as the number of cooperatives grows.
- Private seed companies have only limited direct influence on the quantity of seed produced by cooperatives, since they are only rarely giving contracts for production of specified quantities of a given variety.
- Seed companies have improved seed availability in and near large cities, where they have their offices, seed processing facilities and outlets. They have also improved seed availability for NGOs and government programs conducting seed activities.
- Farmer seed-cooperatives have undertaken various efforts to improve availability of their seed in local markets, or to directly serve farmers in their communes, villages, and own organizations, sometimes in collaboration with selected farm-input shops (Section 5.2.4).
- Grain traders, and some NGOs have sometimes acted as brokers between seed producer cooperatives and farmer seed producers, thus rendering seed available over longer distances.
- Total volume of certified seed represents a small (but increasing) portion of the total seed sown (Section 5.1.3), reflecting (a) farmers' traditional aversion to purchasing seed of staple cereals and the 'newness' of commercial seed; (b) the fact that only parts of the total cropped areas are targeted by breeding programs that offer improved varieties (see box); (c) the extensive cultivation of OPV varieties that farmers manage to maintain as pure seed for at least three years (Deu *et al.*, 2014); and (d) the increasing market share of hybrids due to yield superiorities for sorghum (Smale *et al.*, 2014; Baloua Nebie, ICRI-SAT, personal communication March 2017) and maize.

A clearer understanding of the dynamics of certified seed availability in Mali is obtained by examining not simply seed quantities relative to the total crop area sown (Section 5.1.3), but relative to the cultivated area targeted by breeding programs that offer improved varieties. For example, we estimate that only about 50% of pearl millet production area and 70% of the sorghum production area is currently served with varieties from breeding programs. Irrigated rice seed (half of the certified seed market) serves only about 25% of the total rice production area. Thus, for the dryland cereals, with increasing use of hybrids, considerable potential for growth exists. For irrigated rice in contrast, assuming a ceiling of about 30% annual certified seed use with farmers confident of maintaining purity of their own seed for 2-3 years, the current certified seed production may equal or exceed demand.

The improvement of commercial seed availability in rural areas is thus primarily due to initiatives taken by farmer-managed seed enterprises. These dynamics show promise for sustainability, based on the increasing volume, area and the number of farmers reached (Section 5.2.4; Smale *et al.*, 2016). Private seed companies may be achieving similar progress for peri-urban farmers, although this has not been assessed in detail.

There are two main reasons why farmer cooperatives are making better progress with improving availability of improved seed in rural areas: One factor is simply their location in rural areas, usually engaged in agricultural development for their village, commune, or larger area (Wennink *et al.*, 2012), and proximity to clients with minimal cost. Another factor is their active collaboration with a national research stations and breeders. Farmer-managed seed cooperatives and breeders often plan seed production together, including early generation seed, based

on interest and demands arising from variety trials and joint collection of feedback from other farmers.

Private seed companies, conditioning and packaging their seed in a central facility, have significant costs and challenges to make their seed available to distant and geographically dispersed farmers. Private companies can have access to trial results and experiences of public breeders, but their access to farmer feedback depends considerably on the company's interactions with their seed production partners (seed cooperatives) and clients.

Moreover, seed companies could work in a more proactive manner with client NGO's to build seed trading networks and increase chances of sustained seed availability after the NGO project ends.

Major NGOs engaged in longer-term agricultural and rural development in Mali (e.g. Catholic Relief Service (CRS), Myagro, *Association Malienne d'Éveil au Développement Durable* (AMEDD), *Afrique Verte*) are, however, increasingly working directly with farmer seed cooperatives, often located in their project areas. These NGOs have supported seed cooperatives' direct seed commercialization, including improving participating farmers' marketing, business management, and accounting skills. Expected benefits of more direct sourcing of seed from seed-producer cooperatives include increasing local income generation (e.g. through seed conditioning and packaging), and networking with researchers who can help address other constraints to production.

Farmer seed cooperatives' willingness to take entrepreneurial risks is another factor contributing to improved availability of improved seed. While generally all actors agreed that producing high quality seed is not a major problem, planning how much seed to produce of which variety and for which area is an issue critical for the profitability of any seed business. Farmer seed cooperatives are taking these risks and generally bear liability for unsold seed. Private seed companies, in contrast, are reluctant to give seed-production contracts, mostly buying seed on short notice after certification as the company's markets unfold.

COMPARISON ACROSS COUNTRIES OF MAJOR SEED ENTERPRISE TYPES

To facilitate comparison among the wide range of private seed enterprises interviewed in Mali and Kenya, we classify them based on the seed system functions to which they contribute (Table 12). The differences between these models for contribution to seed system functions are important as they indicate where each is adding value to the system. The first model is the 'farmer seed-producer cooperative', or a union of such cooperatives, that is engaged across most functions, from collaboration with breeders, through production, marketing and selling seed. The second type of enterprises is seed companies that are most strongly engaged in conditioning and packaging seed they purchase, and are thus identified here as 'seed processing and trading companies'. These first two models predominantly operate in Mali. Seed companies, whether privately owned or parastatal, operate along fairly similar seed processing and dissemination paths but differ in whether they invest in their own breeding or depend entirely on licensing publicly bred varieties. 'Breeding Companies' are only found in Kenya (not in Mali) and 'seed companies' are predominantly in Kenya.

One noteworthy difference between the 'farmer cooperative' and the 'seed processing and trading' model is that the former is far more engaged in selling seed to rural farmers. The 'seed companies' and 'breeding companies' are selling considerable and increasing portions of their seed to farmers through distributor/retail networks. The 'farmer cooperative' model differs from the other three models in emphasizing local communication channels for marketing their seed; a further difference is their focus on local (decentralized) seed processing.

Our assessment of the comparative advantages and key challenges for each of these models for contributing to seed availability for smallholder farmers, including women and men, reveals numerous important differences (Table 13). The proximity to clients and organizational capacities are clearly factors of importance. More detailed study of how innovations and strengthening of these factors would contribute to seed industry growth and sustainable gains for smallholder seed availability.

Table 12: Comparisons of major seed business types operating in Mali and Kenya for their engagements in basic seed system functions (EGS=Early Generation Seed).

Seed system function	Major seed business types			
	Union of farmer cooperatives (e.g. Mali)	Seed processing and trade company (e.g. Mali)	Seed company (e.g. Kenya)	Breeding company (e.g. Kenya)
Variety development	Contribute to variety identification, may receive support for contribution to breeding operations, pay for EGS	No investment, indirect contribution via EGS purchase	Pays royalties to KALRO	Conducts own breeding program
Production of certified seed	Produce	Purchase from farmer cooperatives on need basis	Contracts producers	Contracts producers
Seed conditioning and packaging	With local labor for local sale and on demand	Centralized facility, medium throughput	Centralized facility, medium to high throughput	Centralized facility, medium to high throughput
Marketing	Local channels, radio, posters, focus on specific varieties	Limited, national TV, focus on quality of conditioning	Demonstration plots, agricultural fairs, promotional materials	National television, promotional materials, demonstration plots, agricultural fairs
Seed sales to farmers	Predominantly rural; approximately 30% of total volume produced (rising),	Predominantly peri-urban, in rural areas very low; approximately 20% of total volume produced	No estimates received, collaboration with distributors/agrodealer networks	No estimates received, collaboration with distributors/agrodealer networks

Table 13: Assessments of comparative advantages and key challenges for major seed businesses types for achieving seed availability for smallholder farmers (women and men) in Kenya and Mali.

	Union of farmer cooperatives (e.g. Mali)	Seed processing and trade company (e.g. Mali)	Seed company (e.g. Kenya)	Breeding company (e.g. Kenya)
Comparative business advantage	Proximity and trust of farmers for local dissemination; low cost of high quality seed	Proximity to development actors (government agencies, NGO's) for bulk sales	Farmers' confidence in KALRO bred varieties	Focus on variety development and dissemination in areas underserved by KALRO
Key challenges for reaching smallholder farmers (women and men)	Cooperative management, balancing income between members and cooperative	Building low cost dissemination networks	Availability of appropriate hybrids in small packet sizes	Breeding superior hybrids and building 'secured' dissemination network
Contribution to variety turnover in response to farmer demand	Help set priorities for breeding, readily identify new opportunities for specific uses and production contexts	Decisions post-release, responsiveness dependent on strength of feedback loops with farmers and other relevant actors	Dependent on KALRO breeding progress, and policies for licensing	Responsiveness of own breeding program

(Table 13 continued)

Potential for impact on variety adoption and productivity increases of farmers	High potential impact in their area of influence, thus depending on the coverage and number of cooperatives and their capacity to manage seed access on credit, at least to members	Depends on extent of sales network in farming areas; sales to free seed distribution programs have shown little impact as farmers hesitate to use seed of unknown origin (some experienced low quality of distributed seed; little information provided)	Depends on extent of sales network in farming areas; sales to free seed distribution programs have shown little impact (see previous column)	Depends on extent of sales network in farming areas; sales to free seed distribution programs have shown little impact (see previous column)
---	---	--	--	--

Additionally, specific examination of how these models currently respond to farmers' varietal demands and emerging production opportunities, and how each could do better, would help strengthen seed system functioning. Now is an ideal time for such studies, as a wide range of models are developing and the sector is dynamic in both countries; most operations started during the past 10-15 years, with new enterprises continuing to enter the market.

Some specific suggestions for interventions that would improve seed availability for smallholder farmers include:

- Attention and support to cooperative models for seed production and marketing in proximity to smallholder farmers.
- Explore systems and business models for treating seed at the time of sale or sowing to enable unsold seed stocks to be sold as grain (also to respond to farmer demands for specific treatment products).
- Appropriate mid-scale seed conditioning and packaging equipment for farmer seed cooperatives, and mobile equipment for servicing several villages.
- Research on business models for more local seed processing, seed treatment and seed marketing, including assessments of economic viability, rural employment and seed availability to smallholder farmers by current or pilot decentralized enterprises relative to other models.
- Research on seed provision by grain traders as a promising model for proximity and timeliness of seed availability (see also Section 6.2.4).

6.3 SEED ACCESS

Access to seed is defined as farmers having the necessary resources to obtain appropriate seed that is available near to them (Sperling, 2008), be it cash, grain for barter, credit and/or good relations to the person who provides the seed. Access to seed is the final determinant of whether improved seed is sown and can provide benefits to its users.

6.3.1 THE 'SOCIAL PRICE' OF SEED

Farmers exercise healthy levels of caution before accessing seed they do not know, as clearly revealed in the results chapters (Chapters 4 and 5). While trust in the seed supplier and the quality of seed s/he is offering plays a big role (Section 6.1.4), the conditions under which it can be acquired can also be a determinant of access.

In Mali, where cultural norms regarding seed of traditional cereal crops are very strong, taking seed from 'outside', i.e. from another farmer or buying it in the market, are frowned upon and may involve as a loss of status. However, being asked by others to provide seed is a recognition. A person who is asked to provide seed is culturally obliged to give the seed, mostly for free or on an exchange basis; however, the 'seed-to-grain price ratio'

in this system is never more than 1:1 (on a volume basis). Asking for money in exchange for seed is culturally unacceptable. Thus, cultural norms assure access to seed, also for the most disadvantaged persons (CRS/Mali and partners; 2006; Siart 2008).

As a result, the monetary value of seed in this system is actually lower than that of grain, since if at all, grain is typically returned after harvest, when grain prices are much lower than at other times of the year. On the other hand, the 'social price' of seed is high, leading to a situation where it is a priority of farmers to save their own seed and to share it with others if asked. Establishing commercial seed supply options for traditional cereal crops in this context obviously needs to take these cultural norms, farmers' expectations and existing options for seed access into close consideration.

The many and increasing number of farmer cooperative seed enterprises in Mali seem to align with these cultural norms and expectations in numerous ways: Recognizing farmers' capacity to produce high quality seed; observing seed production fields before harvest, with the option to 'pre-order' or express interest to acquire seed at sowing time; paying cash to the cooperative (hence a community action) and not to an individual; or the cooperative offering seed on a barter basis but considering the monetary value. Furthermore, obtaining seed from such cooperatives may provide learning opportunities and interactions with collaborating crop researchers as well as opportunities for grain marketing that may help members to enhance earnings from increasing yields (Wennink *et al.*, 2012), besides creating positive feedback loops for seed purchase.

In Kenya, where maize is an introduced crop, and sorghum is a largely marginalized crop, such cultural norms regarding seed seemed to be very weak. However, the skills and practices to produce and store one's own seed, even in areas like Trans Nzoia County, where hybrid adoption is close to 100%, are widespread and applied regularly, especially by smallholder farmers. This local knowledge is practiced for two reasons: (a) security in case their favorite maize hybrid is not available or the family is unable to mobilize sufficient cash to buy seed; and (b) for seed of local varieties that cannot be accessed otherwise.

6.3.2 THE PRICE OF SEED IN MONETARY TERMS

The price of seed expressed as seed-to-grain price ratios for hybrid maize (ranging from 3:1 to 8:1) and sorghum OPVs (ranging from 2:1 to 8:1), estimated based on the prices farmers indicated paying to seed providers (Table 6), are quite similar in Kenya and Mali. Although our estimates are rough approximations due to limited information and pertaining to the period of conducting interviews, they correspond well with the 5:1 ratio published for maize hybrids in Kenya (Smale and Olwande, 2014).

However, a comparison of the absolute prices of hybrid maize seed in Kenya and Mali, converting prices to US-\$, reveals that seed prices in Kenya can be up to twice as high as in Mali. This seemed to also be true for the maize grain prices observed during the study period.

We further compared seed costs in terms of fertilizer quantities of equal monetary value in each country. These estimates revealed that the cost of hybrid maize seed per ha in Mali reaches the cost of 50 kg of fertilizer, while in Kenya it is approximately equivalent to 100 kg of fertilizer. The relatively high price of seed in Kenya, compared to another input (fertilizer), may help explain why farmers in this country tend to consider the seed price when choosing a hybrid to purchase (Smale and Olwande, 2014).

Large differences exist regarding the amount of seed that is required for sowing one hectare of a particular crop. As a result, the total seed cost per hectare can vary more than one would expect from the seed price alone. For example, total seed cost per hectare for pearl millet and sorghum is low compared to some other crops, including maize, rice or legumes — an issue which contributes to facilitating farmers' access to seed of improved sorghum and pearl millet varieties. Furthermore, total seed cost can have some implications for designing appropriate seed production and distribution strategies for different crops.

the distribution of costs and benefits among different seed system actors in Kenya and Mali. Kenyan farmers producing maize seed sign contracts with seed companies that fix the price for the seed that they produce. This price was reported to be approximately $\frac{1}{3}$ of the retail seed price. Thus, approximately $\frac{2}{3}$ of the seed purchase price paid by farmers cover the costs of the seed company for certification, conditioning, packaging, marketing and distribution, as well as any contributions to the breeding of the varieties. In contrast, the price that Malian seed-producing farmers received for their seed was reported to be about 80% of the price farmers paid when purchasing seed from the cooperatives; thus, the cost for certification, conditioning, marketing and distribution were much lower in this case ($\frac{1}{3}$ of the retail price).

Kenyan seed prices are expected to reflect fairly well the real costs and opportunities for generating revenue — based on the country's long history of hybrid maize use, its more liberalized seed markets since over a decade, and competition among companies for market shares, leading to a significant reduction of the dominance of KSC.

For individual farmers to take informed decisions on seed purchase and expected economic benefits, seed cost (along with other production costs), has to be evaluated against the yield increase farmers can really expect when using commercial seed of certain crops and varieties under their specific agroecological and management conditions. Furthermore, the proportion of grain that is actually sold and the grain price that can be obtained need to be considered. Such assessments can be expected to result in quite different conclusions for individual farmers, also depending on family size, availability of land and labor, as well as other income-generating activities of household members.

The ability to pay for certified seed was mentioned to be a difficulty by smallholder farmers, especially women, in Kenya (Section 4.2.5). Direct cash payments were mentioned as the most common option for accessing seed, except for the KCEP program (Section 4.2.4), which covers part of the seed costs. Thus, appropriate models for individual and group savings and financing, including value-chain financing, could be explored to overcome this constraint in the longer term (Section 6.3.4). However, other options mentioned by interviewees and workshop participants, including smaller package sizes and more selling points closer to the place where the seed is needed, could also facilitate access to seed for some farmers.

Important differences also exist with regard to

The pricing of seed in Mali, in contrast, is something that is evolving. The purchase of seed is a novelty for most Malian cereal producers, except for farmers growing irrigated rice, and thus experiences are still being made regarding setting prices that match sustainable growth of seed businesses with satisfied and loyal clientele.

However, the distribution of revenues among seed system actors in both countries is an issue that deserves further study, particularly in view of the potential of more decentralized seed production and dissemination models, like those that are common in Mali, for income generation in rural areas.

Furthermore, it is noteworthy that in both countries, the actual seed prices seemed not to be in-

fluenced by the very large intra-annual variations in grain prices. A benefit of this situation in Mali is that seed businesses, especially seed cooperatives, can cover their costs even when selling the unsold seed stocks as grain during the pre-harvest season, when grain prices reach the highest level.

Lastly, the direct economic benefit that farmers in Kenya and Mali can anticipate to obtain by purchasing commercial seed of various crops, along with further advantages for yield stability, food and nutrition security or income-generating activities, are also expected to influence farmers' access to seed and would be of great interest for further studies (see box).

6.3.3 THE COST OF FREE SEED

Direct free seed distributions were highly discussed during the individual interviews as well as the workshops in both countries. The farmers who were 'beneficiaries' of seed distributions often expressed discontent due to various shortcomings of way seed was actually distributed: it often arrived late, had a high chance to be of poor quality, and did not always reach the targeted farmers. In Mali, distributed seed tended to be unlabeled or poorly labeled, with no variety descriptions. Agrodealers, as well as other businesses involved in local seed dissemination, were unhappy as they lost business opportunities due to the free seed distributions. On the other hand, some seed companies were rather favorable to such contracts, as they allowed them to deliver large consignments without having the costs for local dissemination. However, they also realized that the free distributions did not contribute to the development of local seed dissemination networks, and that regular distributions made farmers 'dependent' on free seeds. Likewise, Sperling *et al.* (2004) concluded from an analysis of several examples from East Africa that giving 'acute' seed aid, designed to relieve an acute problem, on a repeated basis, has negative effects particularly for vulnerable farmers, local and regional traders, as well as for the development of more commercial seed supply systems — for the same reasons as listed above. In situations where chronic stress prevails, more development-oriented 'seed aid' actions may provide longer term benefits, by strengthening local capacities for seed system functioning, with a stronger focus on poverty reduction (Sperling *et al.*, 2008; Section 4.1.4).

6.3.4 OPTIONS FOR ENHANCING SEED ACCESS THROUGH FINANCIAL MANAGEMENT TOOLS

Limited cash availability or cash flow constraints were mentioned as influencing decision-making and 'room for maneuver' of various seed system actors, including farmers, seed producers and seed sellers. Seed producers reported problems due to the long time period between start of the production cycle and incoming payments, which is longer than a normal agricultural production cycle (see box). Seed sellers could not always meet demands for specific varieties or tended to limit the range of varieties offered to certain popular hybrids (Sections 4.2.4 and 5.2.4). In the case of farmers, limited cash availability was reported by some farmers to restrict access to certified seed of improved varieties (Sections 4.2.4 and 5.2.4), but not access to seed as such, since they relied on their own farm-saved seed or on local networks to ensure access to seed (Section 6.3.1).

The problem of limited cash availability and cash flow constraints in seed systems of Kenya and Mali should be seen in the broader context of similar problems that affect the agricultural sector in developing countries in general, and particularly in Africa. Existing demands for loans in smallholder agriculture tend to be largely unmet, and there is often a mismatch between financial products offered and needs of small-scale farmers — which applies even more to women and youth (Dalberg, 2012; MFW4A, 2012).

A general distinction can be made between long-term investments, e.g. for seed processing facilities or other technical equipment, including buildings (such as storehouses), and seasonal credits that allow normal operations and are usually paid back after sale of the product (ISSD Africa, 2017). Different financial tools are available for each of these areas of demand.

The main instruments for long-term investments are own savings, group savings, microfinance, bank loans (sometimes in combination with guarantee funds, see below), or grants. Savings have the advantage that they

Seed producers suffer from a structural cash-flow problem, since they can usually sell their produce only at the beginning of the following season, which means 3-6 months after harvesting. During this entire period, their capital is 'locked' in the stored seed, while at the same time other expenses occur already to prepare for the coming production cycle (e.g. purchasing Early Generation Seed).

Source: ISSD Africa (2017)

do not create obligations for repayment in the future, and are free of interests. In practice, they are often combined with informal credits provided by family members or friends, offering flexible modes of payment if necessary. Group savings and microfinance include some social control, but amounts available are usually limited. Bank loans may be difficult to access for small-scale actors, involve high interest rates and tough collateral conditions; however, they may be suitable for large amounts and long-term investments. Guarantee funds can help small-scale actors to access bank loans by bridging the gap between credit providers' requirements and

clients' conditions and needs. Grants are usually distributed to some selected actors or target groups (=not accessible to all) and are as such not sustainable financing tools; however, they can help 'upgrade' facilities within short time and reduce risks involved in large investments (ISSD Africa, 2017).

For short-term, seasonal financing some further options exist, besides those mentioned above, most of which work also for short and medium term investments. One particularly interesting option is value-chain financing, means that the buyer of the final product, be it seed or grain, provides credit to those who produce it. One highly recognized trader in Kenya, Smart Logistics Solutions Ltd.⁵¹, in fact emphasizes this in her business model, by organizing clusters of smallholder farmers for effective logistics but makes contracts with each farmer individually for personal accountability and transparency.

One further example is the 'out-grower' scheme, which is common for seed producers in Kenya, who have contracts with seed companies. Part of the contract is usually that Early Generation Seed and other inputs required are provided on a credit basis (Section 4.2.4). Further models were reported to be practiced by grain traders in Mali, providing farmers with inputs like improved seed to get the desired quantity and quality (Sections 5.2.4 and 5.2.5), and by seed-producer cooperatives to their members, in both cases on an in-kind basis (credit provided is set off with seed or grain sold at the end of the season).

The main advantage of the above-mentioned forms of value-chain financing is that the buyers, e.g. seed companies or grain traders, are often larger enterprises that suffer less from cash-flow constraints than the producers, or that can more easily access bank loans. A further form of value-chain financing is pre-order systems, where clients order seed in advance and substantiate their order with an advance payment, which covers part of the production costs. This system has been reported to work well for Early Generation Seed in several African countries (ISSD Africa, 2017).

Certain NGOs in both countries also facilitated access to seed by organizing input credits, as well as organizing smallholder farmers for improved output market access. An alternative to such credit-based options for seasonal financing are farmer savings-programs for input purchase. One such program in Mali seeks to facilitate farmers to save money when they have cash at hand (after harvest for example), using a cellphone layaway plan, with

⁵¹ For further information, see <https://www.wfp.org/purchase-progress/blog/kenya-smart-logistics-how-fe-male-trader-helps-smallholders> (22 November 2017)

which they purchase a selected package of inputs (www.myagro.org). The program has seen rapid growth over the past two years, apparently meeting widespread needs — with a high rate of success⁵².

6.4 CROSS-CUTTING ISSUES

The issues of gender and communication are examined in separate sections as their implication in seed system functioning cuts across the elements of seed quality, availability and access. These issues are of particular importance for poverty alleviation, for empowering those with less resources, and for contributing to whole system change.

6.4.1 GENDER

Developing gender perspectives in agricultural research is not only a political issue, as it is often understood, but can be seen as part of a general approach to improving the scientific understanding of agricultural systems, and to better understand the needs for, as well as potential benefits of, new technologies for specific groups of users. For example, gender differences in preferences for specific varietal traits can be expected when women and men farm under different conditions, if they have different roles and responsibilities in the production process, grow the crop for different purposes, or if crops are grown only or predominantly by either women or men (Christinck *et al.*, 2017).

Against this background, gender issues that impact the functioning and value obtained from seed systems for the staple cereal crops in Mali and Kenya are examined here in the context of the diverse agroecologies and production systems covered in this study. As the sample sizes in each case were small, the following statements and findings are best treated as hypotheses that merit further detailed study and investigation.

GENDER, VARIETAL ATTRIBUTES AND DIVERSITY

Grain quality for use as food is a gender issue: Whereas good food qualities of grain are important for both men and women, women responded in greater detail on grain quality traits. This likely reflects women's roles in processing grain and preparing food for the family, and in some cases, having the final word regarding grain quality when crop production is used for home consumption, as indicated by the interviewee who abandoned a new variety after the first year due to his wife's insistence due to poor grain quality (Section 5.2.5). Often linked to grain quality are concerns about the storability of grains, another domain often under the responsibility of women. Obviously, grain storability, food processing and food quality traits are primarily important to farmers who grow these crops for home consumption and family food security and less so for larger producers who are only engaged in commercial activities.

Grain quality and processing traits were generally not found to be high on plant breeders' priorities, with the exception of sorghum in Mali (Rattunde *et al.*, 2017). It appears that particularly the improvement of maize varieties and hybrids in Kenya for storability, food quality and food safety traits (Section 4.2.5) would provide important benefits to women farmers and smallholder farmer families who most depend on their maize production for food security.

Women, especially in Kenya, not only mentioned more specific aspects of grain quality but were actually growing more different varieties for specific food purposes compared to men (Section 4.2.5), including varieties with different colors of grains. Women were thus contributing actively to the maintenance of varietal diversity, especially in Homabay County. For sorghum, a similar situation was encountered in both Homabay and Tharaka Nithi Counties, where women used and maintained varieties with specific grain quality for particular purposes.

⁵² Jorre Vleminckx (MyAgro), personal communication (October 2017)

Another complex of varietal traits with significant gender consequences is that of adaptation to soil fertility conditions, as women's fields often show lower levels of soil fertility compared to men's fields, especially in Mali (Rattunde *et al.*, 2017). For Kenya, more detailed analyses of gender and production system dynamics would be required to determine if similar differences exist.

Ensuring seed availability of specific local varieties appears to be an issue of importance not only to smallholder farmers in general, but particularly to women farmers (Sections 4.2.1 and 5.2.1, see also box on this page) and was put forward by women in both country workshop discussions. Furthermore, in a recent study including female-headed households in Kenya, these were found to grow less hybrid maize than male-headed households, even if differences regarding asset levels of both groups were considered (Smale and Olwande, 2014).

Women's apparent greater preference for local varieties is thus expected to be due to several reasons: Local varieties were often indicated to have superior grain quality and adaptation traits, which may be of greater importance to women given the conditions under which they engage in farming and their responsibilities for grain storage, processing and preparation of food. Also, women may be less inclined or able to invest in hybrid seed — for reasons that would need to be explored.

GENDER AND COMMUNICATION

Communication about varietal issues and seed availability require explicit efforts so that women as well as men can receive information, have a voice and can give input. For example, most women interviewed in Kenya had never been invited to a field day or had visited demonstration plots, mostly because they were too far away, whereas men mentioned such activities more frequently..

Some women also felt that distant demonstration plots may be less pertinent for them as the growing conditions may not represent their field conditions. The Malian women who conducted on-farm sorghum or pearl millet variety evaluations on behalf of their cooperatives appreciated the options of testing new varieties as intercrops (corresponding to their typical production system), as well the options of splitting test plots in half and applying their own and an improved management-practice on each half. Such a system allowed the women, as a group, to assess how new varieties performed under current conditions as well as under improved soil fertility conditions.

It further seemed that interaction among women in their groups was also an important factor for learning, and particularly for the women who did not have their own test plots. These examples indicate that specific 'women-friendly' options for observing new varieties can or must be created to better meet women's specific needs and situations.

Building communication plans on an understanding of women's and men's local organizations, considering their time plans and availability during the day and week for their farming-related activities, considering their access to radio, weekly markets and telephone services, and focusing on issues that they are concerned with are critical for successful information sharing in a gender-responsive manner.

Women's more detailed knowledge and elucidation of grain quality (Sections 4.2.5 and 5.2.5) and other issues related to post-harvest processing can be critical for the success of breeding and seed programs. It may thus be necessary to identify communication tools and ensure feedback loops so that breeders and other actors in the seed production and distribution system can benefit from women as well as men farmers' knowledge and consider their experiences in the decisions that they make.

GENDER AND SEED DISSEMINATION

In this study, women directly or indirectly mentioned distance to the nearest seed supplier as a hindrance to seed availability in both Kenya and Mali. Women's more limited access to transport options and time constraints may well be factors that make proximity of seed sales points of particular importance for women.

Cash availability and risk aversion also appeared to be issues especially hindering women's access to new seed. Having cash at hand at the time of sowing appeared to be challenging for smallholder women farmers in particular. Women's reticence to purchase certified seed and greater reliance on local varieties was most pronounced in areas subjected to higher risks of crop failure, particularly for maize, sorghum and pearl millet.

Even in the irrigated rice system in Mali, smallholder women farmers reported how they did not want to take the risk of buying seed of unknown quality as they had only one small field and were unwilling to risk crop failure in view of their production investments (water, fertilizer and possibly labor) and that their plots were too small to test new varieties. Women's first-hand experiences with new varieties, possibly via test or demonstration plots conducted by a women's group in their village, appears to be particularly important for poorer women in more risk-prone environments.

Women in several counties of Kenya spoke out clearly about their desire to buy smaller (1kg) packets of maize seed whereas the smallest packets offered are 2 kg. Women tend to have smaller fields, often growing a wider range of crops for direct consumption, and thus often need smaller quantities of seed. Seed companies indicated their reluctance (*"inability"*) to routinely offer such small packets but reported producing them on special order for large consignments, e.g. on orders from an NGO. It should be possible to respond to women's demands for smaller seed packets in Kenya considering how other consumer products are sold in small, single-use packets and that Malian seed cooperatives are routinely selling various packet sizes (0.5, 1, 2 and 5kg packets) and even have experience selling 100g packets for farmers to test new varieties.

However, women should not only be seen as seed customers with special requirements, since their capacity for production and sale of seed also appears to merit much closer attention. Women seed cooperatives in Mali are producing certified seed, even hybrid seed of sorghum, as well as successfully marketing and selling their seed. Additionally, certain Malian seed cooperatives learned when exploring options for increasing seed sales to surrounding farmers that women, often younger women, were highly successful seed sellers, especially at the weekly markets. One reason for their success may be that women are less bound by social norms and stigma associated with selling or buying seed. It was also mentioned that women could be more trusted, both by men and women, and if women were convinced of the merit of a new variety and had positive experiences, then that variety would likely be good for them in their own situation. Although such experiences were not reported in Kenya, further experimentation with female seed sellers would seem worthwhile in both Kenya and Mali, especially where new varieties become available and seed-seller networks and extension support are weak.

Although we could not adequately assess the pathways women commonly use for getting seed, there are reports from Mali that women traditionally obtain seed of rain-fed cereals from their husbands and thus often have limited choice of varieties to grow. However, women who are engaged, or in contact, with women's groups that conduct variety tests or produce seed reportedly had increased awareness about the differences among available varieties and tended to start keeping seed of new varieties or purchasing small packets themselves. This appears to be another example of how strengthening social capital, especially among women, can contribute to improving seed system dynamics as well as increase women's chances to be successful farmers and/or to run successful seed businesses.

6.4.2 COMMUNICATION

The desire for more and better information was expressed by people active across the full spectrum of seed system functions, from those who purchase or produce seed, to government seed regulatory agents and breeders. The high priority given by participants of both country workshops to strengthening stakeholder meetings at

various administrative levels (Sections 4.3.3 and 5.3.3) underlines this felt need. The willingness of the various actors to work and discuss together was evident in both workshops and represents a positive energy to be tapped for collective action at larger scale for seed system development.

Many issues on how information exchange among various seed system actors could be improved to help actors make more informed decisions were raised in the interviews and workshop exchanges. We examine here the aspects of quality of the information exchanged, the inclusion of different types of actors for sharing information, and modes of communication for exchanging information at large scale and enabling joint learning.

PERTINENCE AND QUALITY OF INFORMATION

A major question that emerges from considering smallholder farmers' preferences for specific varietal traits and the varietal information currently being disseminated, whether by variety catalogue lists, promotional pamphlets or demonstration plots, is *"How well does the information provided address the priority interests and needs of smallholder farmers?"* One type of varietal information of particular importance to smallholder farmers that could be strengthened is that of the quality of grain for consumption and storage. Strengthening of grain quality assessments during varietal characterization and inclusion of those results in variety promotional information would be useful. Likewise, inclusion of information on varietal performance under various levels of soil fertility would be particularly helpful to smallholder farmers.

Varietal adaptation information is clearly of utmost importance but also very challenging to provide in a way that it is pertinent for different types of farmers, and ultimately for individual farmers with their specific conditions and objectives. The current indications of varietal adaptation by broad altitude range or very broad rainfall ranges gives some guidance, but are clearly insufficient. Demonstration plots may give farmers information of local importance, although the question remains of how well the demonstration conditions correspond to those of individual farmers and exactly what can or cannot be observed. Furthermore, public access to quantitative and independent information for comparison among varieties is rare, and appears to be a major gap.

The decentralized system of regional trials established in Germany (*'Landessortenversuche'*), for example, established to provide impartial varietal information of regional pertinence, offers an excellent model for providing region-specific information for comparing varietal performances, and regularly attracts many farmers. Although such a system does not currently exist in Kenya or Mali, the Kenyan county extension agencies are well placed to develop such a service if they could mobilize the necessary support. Enabling public access to existing data, as for example the NPT results in Kenya, could also contribute to this objective.

An interesting possibility for collecting geographically 'fine-grained' and smallholder-pertinent performance data is offered by large series of on-farm demonstration plots. Although vast numbers of demonstration plots are conducted annually for promoting new varieties, we are not aware of varietal performance data being collected from them. Developing a system for collecting and accessing such information, together with inclusion of appropriate check varieties in each demonstration plot, could provide a low-cost and more geo-spatially refined source of variety performance information. Providing more user differentiated varietal information, appropriate for specific conditions and types of smallholder farmers, should provide a springboard from which these farmers, either individually or in groups, could pursue their own innovation strategies according to their capability and agroecological potential (Gatzweiler and von Braun, 2016).

INCLUSION OF ACTORS

As effective seed system functioning depends on close relationships among the different actors, the inclusion of a wide range of actors in information networks is obviously important. For example, more inclusion of credit and financial actors appears to be useful, as several seed producers and seed sellers indicated how credit providers needed to better understand the seasonality of their activities. Explicit efforts to include women farmers seems

to be needed, as indicated by the high frequency of women interviewed who had never been invited to demonstration plots or field days.

Inclusion, from our experience, also goes beyond simple physical presence. The manner in which information is shared can also determine access as well as effectiveness of communication. For some groups of farmers, particularly women, issues of distance, language, gender norms and household responsibilities can be factors hindering inclusion. For example, discussions with women farmers about their sources of information about new varieties revealed that written descriptions or pamphlets were almost never mentioned whereas personal and oral communications were frequently cited. One revealing case was the appreciation and enthusiasm of some women farmers regarding an agrovet who made personal visits to their self-help and table-savings group meetings to tell them about new varieties.

Inclusion in communication networks also involves the feasibility of giving input as well as receiving information. One example is that of women farmers in Kenya who suggested that seed companies' station representatives be located in their areas so that the women could give feedback as well as receive information. Another case was how the practical seed-quality control measures proposed by women seed producers was met with strong resistance by some participants at the Mali workshop, raising questions of how their ideas can be heard and considered, and how smallholder farmers can better give input into seed initiatives intended to serve them.

MODES OF COMMUNICATION FOR LARGE-SCALE INFORMATION SHARING AND JOINT LEARNING

One major communication challenge is how to enable millions of smallholder farmers to gain access to varietal information of pertinence to them. Various models currently are being developed to help farmers access information of regional importance at large scales. Below are examples of such models that we encountered in Kenya and Mali:

- MbeguChoice (www.mbeguchoice.com): An online varietal search tool for Kenya that lists whatever varieties in the database match certain broad search categories selected from drop-down menus. This tool represents a start at enabling wide farmer access to varietal information but does require internet access and literacy. Such a system could be advanced by providing more detailed varietal information (including zone-specific performance), inclusion of variety traits particularly desired by smallholder farmers, and access to impartial data for comparing varieties.
- MYAGRO-Mali (www.myagro.org): An NGO offering farmers packages of extension services, seed and fertilizer that can be purchased using a mobile layaway platform; MYAGRO does some local testing to choose varieties it offers and monitors yield performance of both client- and control-farmer plots to monitor economic benefits. This information is currently generated for use by MYAGRO staff (Jorre Vleminckx (MyAgro), personal communication, March 2017).
- FIPS-Africa (www.fipsafrica.org): An NGO pursues an approach of initially distributing tiny packets of seed, enabling farmers to sow enough plants to gain an impression of the performance of a new variety under their own field conditions. This model relies on village advisors who maintain close contact with smallholder farmers, offering them information and selling seed on commission.

All of these models represent interesting approaches to provide information to farmers at a large scale. Yet, they are all designed and implemented in a more top-down manner, while there appears to be some emerging efforts at gathering information on varietal performance at the farmer level (see also workshop discussion, Section 4.3.2, Table 7). Strengthening that capacity would be highly desirable. The ability to gather information on farmers' experiences with specific varieties and production contexts would be yet another, major step forward that could build on the 'traditional' method of farmer-to-farmer exchange networks. New communication technologies using applications for use with mobile devices, farmer-to-farmer video messaging etc. can be used to accelerate and scale up knowledge sharing.

However, input of new options and ideas provided from other actors is still needed to enhance farmer experimentation beyond what resources they already have. Adding capacity for data and knowledge gathering to large-

scale development approaches (such as FIPS-Africa or MYAGRO) and the ability to have that information accessible to different actors could offer considerable possibilities for joint learning.

In general, collaborative learning of actors with diverse and complementary expertise is powerful for creating collaborative advantages and facilitating innovation (Hoffmann *et al.*, 2007; see also Section 3.1.6, Figure 2) innovation, and has proven to be highly relevant for seed system development as well. One example is the collaboration between seed-producer cooperatives and plant breeders in Mali (Christinck *et al.*, 2014), which evolved from joint learning experiences in participatory variety evaluation. This activity provided farmers with rapid access to varietal information pertinent for their conditions and production objectives, while they in turn gave direct feedback to the researchers on varietal performance and demand for new varieties. This model is achieving some scale in Mali, with individual breeding programs collaborating with numerous cooperatives, associations or unions of cooperatives.

Most recently, communication technologies are sought to meet the challenges of effectively sharing variety- and seed-production and sale information in ever enlarging networks, and to attain large-scale impact by effectively sharing information with the multitude of surrounding farmers. One Malian farmer union's response to the challenge of internal communications within and among its 40 cooperatives was to set up local seed committees for clusters of villages that facilitated information flow within the local area and two-way-exchange with a central seed committee (Mamourou Sidibé, personal communication. March 2017).

Developing new communication tools in the context of established, functioning networks is both a pressing need and an opportunity for joint learning. The networks have a large base of information to be shared and large farmer-membership and other seed actors who are keen to access information of local relevance in a timely manner. Tools generated and lessons learned through such communication developments would certainly be useful for a multitude of such networks engaged with different crops in various countries.

6.5 REFLECTION ON METHODOLOGY AND RESULTS OBTAINED

The actor-oriented approach, introduced in Section 3.1.5, is widely recognized for being suitable for investigation of local outcomes of 'external' interventions, such as policies and legal frameworks. Furthermore, it facilitates understanding of the ways in which actors and institutions in localized settings are influenced by such interventions. Legislative and institutional frameworks for seed systems in African countries are typical examples of such situations, where important policy decisions are taken in settings that are framed by international organizations and experts, with little consideration of the multi-faceted realities encountered by local actors (Haugen, 2015).

Thus, the actor statements presented in Sections 4.2 and 4.3 for Kenya, and 5.2 and 5.3 for Mali, are the main new 'data' generated through this study, offering 'insider' perspectives of the functioning or dysfunctioning of seed systems at local levels in both countries, based on experiences shared by more than 450 interviewees across countries and study regions (Sections 3.2.5 and 3.2.6). The reliability of the results has been ensured by sequencing and triangulation, methods that are commonly applied to validate results in participatory and qualitative research (Golafshani, 2003; Narayanasami, 2009). For example, suggestions that were made initially by individual interviewees to address or overcome existing problems were further discussed in small groups involving various seed system actors, and finally in plenary discussions. Semi-structured interviews were followed by facilitated group discussions and ranking exercises. Furthermore, interviews were mostly conducted and evaluated in teams, often including researchers from various disciplines, to make sure that issues raised were understood, documented and jointly reflected upon from different angles, to reduce personal or disciplinary biases. The workshop results (Sections 4.3 and 5.3) in particular show how proposed actions were discussed and prioritized by the participants in a step-wise process, while also showing major areas of conflict and dissent.

What the information provided in this study can offer is a broad diversity of actor perspectives, which is larger than in most other studies, given the inclusion of eleven different actor categories and further differentiation

Discussion

within several of these categories (Section 3.2.6). Thus, the actors' experiences with seed systems in Kenya and Mali draw a detailed and diverse picture, which contributes to deepening understanding of seed systems in general, and the diverse interrelations between seed system functions in Kenya and Mali in particular.

The actors' assessment of problems, relationships and options for improvement allows for the identification of a range of issues that deserve further study and practical exploration (Sections 6.1 to 6.4). Furthermore, entry points for practical actions that are relevant to some or all actors were identified (Sections 4.3.3 and 5.3.3, Chapter 7, Annex E). Hence, even though the assessment of actor perspectives can obviously only be based on those actors' contributions who are currently involved in seed system activities, the proposed actions provide opportunities for others to also align with them and/or contribute to the expressed needs and goals through their own initiatives.

Limitations of the study are (1) the limited time for conducting the field work, resulting in constraints regarding the identification of actors beyond those who were spontaneously willing and able to participate (as reflected, for example, in the lower percentage of women participants in workshops); and (2) the low number of similar actors within each of the eleven categories, in spite of the large number of interviews conducted, limiting the possibilities to compare results within and across actor categories. The fact, however, that so many people contributed and participated voluntarily shows the high level of interest and commitment among local seed system actors to contribute to seed system improvements — a resource on which future research should build.

7 CONCLUSIONS AND ENTRY POINTS FOR SEED SYSTEM IMPROVEMENT

In this final chapter, the opportunities and entry points for seed system strengthening are distilled from across the field interviews and workshop discussions. These topics and specific suggestions, synthesized below, can serve as an agenda for sustainable seed system development, especially for staple cereals in Kenya and Mali. Detailed action opportunities, addressing specific crop and country contexts, can be elaborated from each of these entry points and are presented in Annex E.

The proposed agenda includes stronger actor and farmer orientation (7.1 and 7.2); improved collection and sharing of varietal information (7.3); a strong role for farmer groups and cooperatives in seed system development (7.4); and a clear focus on variety development as a source of innovation in seed system development (7.5). We further suggest that resources should be moved from control and ‘relief’ activities towards facilitation of creative and innovative approaches (7.6). Concluding remarks (7.7) are presented in the closing section of the chapter.

7.1 ACTOR ORIENTATION: A VITAL AND COMPLEMENTARY PERSPECTIVE FOR SEED SYSTEM DEVELOPMENT

The collective purpose of a seed system, introduced in Chapter 3.1, is to provide farmers and other actors with high quality seeds of a wide range of varieties and crops in sufficient quantity, at an affordable price, and in a timely manner (FAO, 2017). As a system, its functioning depends not only on the capacities of individual actors, but also on their relationships (Capra and Louisi, 2014). The development attained by an individual actor thus

depends on the nature and health of his or her relationships with others in the system.

“You can’t grow alone” – the title of our report – was taken from a statement made by a grain trader from Machakos, Kenya, who aggregates grain from farmers to supply food and feed industries. In her interview, she highlighted the importance of transparency and trust among actors, and emphasized the need for farmers to see and realize benefits in order to enhance her own business.

Important aspects of sustainable development, such as resilience, adaptability or increased capabilities of actors, are in fact to a large degree supported by human relationships, including the capacity to relate and adapt individual actions to collective purposes.

Seed system development is thus not only based on economic opportunities, but also includes social, ecological, cultural and ethical dimensions.

Consideration of how interventions can contribute and build on these multiple dimensions could increase their effectiveness in enhancing the current seed systems. The actor-oriented approach used in this study proved to be very useful for obtaining insights into these different dimensions as they relate to seed system functioning. These insights complement a more quantitative description of these systems, particularly where the system is conceptualized only as a linear model of a supply chain.

A further advantage of the approach is its built-in link to action. Understanding all the necessary details to choose the appropriate actions can be a lengthy and possibly costly process. The actor-oriented approach addresses this issue by involving all actors in a collaborative learning, implementation and evaluation process. Bringing seed system actors together in this study, including farmers as key actors, and facilitating their participation, made the opportunities and advantages of improved cooperation tangible. The participants highly valued this experience. Even in the short time available for this study, a range of suggestions were made that could be put in practice, even at large scale. To take advantage of this process, it would be useful to consider how such initiatives could be supported and followed-up in the near future.

7.2 “FARMER FIRST” – A NECESSARY PERSPECTIVE

The farmer was emphasized as a central figure in this actor-oriented assessment, as the genetic and seed-related benefits need to be realized by the millions of cereal farmers in Kenya and Mali before benefits can accrue to other actors in the system.

Thus, seed system development in Mali and Kenya needs to create new opportunities for large numbers of small-holder farmers and their families to increase the value of their cereal production. A foundation for this development is a growing understanding of farmers’ skills, capacities, values and uses of the products, as well as their production constraints and opportunities. Using the farmers’ perspectives on these issues provides entry points for sustainable seed system development and innovation. Initiating such a development path can start with simple measures, like packaging seed in small packet sizes, facilitating information exchange between farmers and other actors, labeling seed packets with information useful for farmers, enhancing farmers’ skills for production of quality seed, building local seed storage facilities, or establishing seed sales points close to farmers. Such efforts should be accompanied by measures to improve communication skills and strategies for diffusion. The confidence and positive experiences gained will lead to up- and out-scaling and further joint learning.

The interactions in this study clearly showed the need to include farmers, and a sufficient diversity of farmers, in developing improved seed system options. Many seed system interventions, including plant breeding and seed

The most important change needed for sustainable development of the Malian seed system was to “free the voice of farmers so that they can express their true needs, and that these are regularly listened to”, according to one public institution researcher responsible for on-farm breeding activities. This was seen to be “a large challenge that requires work on changing mentality and building confidence between people. So long as farmers are only considered as beneficiaries little progress can be expected.”

dissemination activities, revealed examples of how lack of partnership with farmers resulted in serious waste of efforts, missed opportunities, or even crop loss or increased risk for farmers. It is thus necessary that seed system development supports and implements interventions and investments using a farmer-centered, actor-oriented approach.

However, just saying that a program is ‘farmer centered’ is not enough; there must be the interest and capacity to implement an effective and iterative engagement, with continual joint learning (see box). This is not exactly the same as ‘organizing a seed system based on farmer demand’; the difference is that farmers can either

be conceptualized as more or less passive ‘adopters’ of varieties and seed (thus creating a ‘demand’ for actions of others), or as active ‘players’. The latter approach recognizes that farmers are contributing to the various seed system functions, they can cooperate with other system actors, and they are producing the majority of seed.

7.3 IMPROVED COLLECTION AND SHARING OF VARIETAL INFORMATION AND PERFORMANCE DATA

The capacity to collect and share information about varieties (and their comparative performances) among farmers and between all actor types needs to be strengthened, as this is vital for a dynamic, responsive seed system. Strengthening farmers’ variety evaluation capacities while enabling breeders to characterize performance in specific environments and for key traits not currently addressed, would add valuable information and dynamics to the system. Assessing performance from demonstration plots and other extension efforts will generate information that farmers, seed sellers, distributors and companies can use for decision-making and planning.

Enabling public access to results of national performance trials is one specific opportunity for enhancing information sharing. Assuring not only access to these results, but also transparency about specific reasons for release of new varieties would be useful. Other opportunities for information sharing include: training and use of new IT

tools such as applications for cell phones and other mobile devices, video, or radio; varietal descriptions that include environment-specific performance and key weaknesses as well as strengths; making variety catalogues searchable online (Mali); improving labeling on seed packages; and revitalizing extension services.

Improving the collection of data on varietal performance is something to work towards for enhancing Kenyan and Malian seed systems. The compilation of variety performance results from on-station trials, farmers, and demonstration plots on regional or national scales would build large and growing data sets ('big data') to inform seed system actors on the performance and the profitability of alternative varieties. Combining information on the corresponding production conditions (soil, rainfall, pests and diseases) with performance data would enable context-specific queries. Coupling information-capture activities with development and humanitarian project activities is a big opportunity for building up pertinent databases on varietal performance and profitability for diverse farmers and production conditions. Appropriate data-management, analysis and IT tools for sharing this information in user friendly ways could make major contributions to better informed, and better functioning, seed systems.

7.4 STRENGTHENING FARMER COOPERATIVES AND THEIR NETWORKS

Farmer cooperatives and associations conduct many seed system functions for staple cereals in Mali. Certified seed in Mali was mostly produced by farmer cooperatives and the seed purchased by farmers was often sold by nearby cooperatives. Factors contributing to this is that cooperative models are a good fit to the ecological and socio-cultural context and are supported by social values. This is particularly true for smallholder farmers for whom food security, as well as market considerations, are priorities. Critical elements are (1) knowledge that the varieties are suitable and adapted to their conditions, and (2) trust in the people involved.

A number of farmers in both Mali and Kenya were concerned about maintaining their local varieties or troubled about their loss. Several Kenyan farmers suggested enhancing farmer cooperation to resolve their problems with sorghum and maize seed. Cooperative models offer advantages for seed sovereignty, with farmer members having a voice in strategic decisions on seed issues.

The development of decentralized seed enterprises based on farmer-groups where market opportunities are not favorable for large-scale seed companies or farmers need diverse varieties is not new. Such enterprises had developed earlier under such situations in Europe and the United States, with some major seed undertakings today tracing their histories back to this origin (see Section 6.2.2; Harwood, 2012).

While farmer cooperative members were aware of the challenges associated with cooperative governance, finance and asset management, they appreciated the advantages for varietal choice, seed quality and cost, and income opportunities of a farmer-managed seed supply and dissemination system. For some seed cooperative members, their service to the community was also important.

Networking among seed cooperatives tends to speed the learning processes – learning from each other. It also facilitates interactions with other seed system actors. For example, breeders can more easily engage in collaborative variety testing and identification at a regional level with a functioning network of seed cooperatives. Many Malian plant breeders appreciate this opportunity offered by the farmer seed-cooperative business model. Collaboration with farmer groups can accelerate delivery of new varieties to farmers — a known bottleneck of publicly funded breeding programs — as well as providing business opportunities. The production and marketing of

The positive role of farmer seed cooperatives for effective seed delivery to farmers was reported in Ethiopia, West African countries, and Nepal (Thijssen et al., 2008; Dhakal, 2013; Christinck et al., 2014, Sisay et al., 2017). However, not all experiences with this business model are positive. AGRA, for example, has discontinued its support to twelve farmer seed cooperatives even though this was initially an important part of their strategy to get seed to farmers (Dr Joe de Vries, personal communication via e-mail, 6 June 2017). GIZ, on the other hand, has recently started running 'farmer business schools' in Mali, with encouraging positive results (Dr Rokia Goldmann, personal communication via e-mail, 16 May 2017). Whether farmer seed cooperatives are functional and sustainable depends on many factors such as internal group dynamics, the nature of extension support, quality control mechanisms applied, and the seed marketing approach taken (Dhakal, 2013). This author also found that organizations developed by farmers' own initiatives and group actions implemented autonomously had long-term impact on ownership and performance. Similarly, Thijssen et al. (2008) presented cases studies where farmers' full responsibility for managing and operating their enterprises, combined with tailored support for technical, organizational and management skills, contributed to their success. Based on results of our study, we would add that the nature and quality of relationships with other actors and institutions, e.g. plant breeders, seed certification agents and seed sellers, is another important factor for success.

breeders' engagement with other system actors, from variety creation through dissemination, for effective seed system functioning. The improved information flow resulting from better linkage of breeders with other seed system actors will simultaneously help orient breeding programs to farmers' priorities and expand the portfolio of varieties accessible to farmers. Farmers' interest to strengthen their groups' capacity for variety testing requires breeders' involvement which could, if properly organized, enhance effectiveness of breeding for specific environments and/or environmental stability. Farmers suggested a wide range of plant traits for improvement, with several quality traits for home-use and processing highlighted for which smallholder farmer-breeder information exchange and collaboration would be most useful.

Our diverse and intense interview discussions about varietal characteristics suggest that seed system advancement depends on a clear and shared understanding of the type of innovations that are actually needed. Breed

hybrid sorghum seed by farmer cooperatives in Mali, as well as large Kenyan grain traders collaborating with farmer groups for seed inputs and grain output marketing, are such examples. Enhanced collaboration among farmers and farmer cooperatives can also open other opportunities such as grain marketing with volumes and qualities of commercial interest and reliability.

Public funds in both Mali and Kenya currently support many seed system functions and actors (e.g., breeding, early generation seed production, seed quality control, and seed dissemination, including free distribution of seed to farmers). How, or if, these investments lead to sustainable seed system development, including financial viability, ecological and social benefits, appears to be poorly analyzed or documented. Consideration of how public support for farmer cooperative capacity building could contribute to seed system development seems warranted, particularly in view of the highlighted needs to shorten distribution pathways, reduce transaction costs and improve information flow.

7.5 INTEGRATE PLANT BREEDING AS PART OF SEED SYSTEM DEVELOPMENT

Suggestions made by interview partners for promoting farmers' access to new and established varieties included maintenance of and access to 'old' (improved) varieties with preferred traits; improving farmers' local varieties and their dissemination; enable seed enterprises to build their reputations by offering farmer preferred varieties; and enhancing seed sellers' knowledge of available varieties.

These suggestions indicate the need for plant

Crop varieties can make multiple contributions to food and nutrition security, including the availability of, access to, and proper utilization of food (CFS, 2012). Neither 'modern' high yielding varieties nor traditional varieties are better per se for addressing the range of food security challenges in developing countries. Each often targets different aspects of food and nutrition security and provides different benefits to various groups of farmers. For example, many farmers manage environmental risks by maintaining local varieties alongside 'modern' varieties to cope with challenges arising from diverse, heterogeneous and variable environmental conditions. Furthermore, specific varieties, including local varieties, are maintained for their post-harvest characteristics (food yield, nutritional value and taste), for buffering seasonal variation in food availability, for ensuring access of individuals to food of required quantity and quality, or for price premiums (Jarvis et al., 2011; Christinck and Weltzien, 2013).

ers' discussions with farmers and their market partners' about actual needs contribute greatly to this end, particularly if they are conducted openly and irrespective of which type of variety (e.g. local or 'improved', open pollinating or hybrid variety) exhibits the preferred traits (see box).

Food security, a major objective of Sub-Saharan plant-breeding programs and seed system interventions by government actors and agricultural scientists alike, tends to be interpreted as staple grain self-sufficiency and yield (Pingali, 2015). Supply side emphasis of agri-food systems interventions tends not to address the actual needs of different population groups for food and nutrition security in comprehensive ways, nor at the necessary level of detail (McDermott et al., 2015; Pingali, 2015).

Hence, a focus on yield alone is too narrow for breeding programs to contribute effectively to food and nutrition security. Establishing effective dialogue and feedback loops between plant breeders, farmers, food processors and consumers can enhance and possibly broaden the gains

made by plant breeding and result in more options for value creation at different levels.

7.6 MOVING RESOURCES FROM CONTROL AND RELIEF TO CREATIVITY AND RESILIENCE

Various concerns were raised regarding the negative time and cost consequences of seed control measures, the insufficiency of resources for seed control (especially Mali) and varietal creation (Kenya and Mali), and the negative consequences of free seed distributions on seed systems (Kenya and Mali). All public breeders flagged funding problems, to the point that efficient, longer-term breeding cannot be implemented. Costs to the system do not only arise financially, but also in terms of delays of getting seed of newly improved varieties to farmers. There may also be costs in terms of loss of diversity in the system if controls are inappropriate. Key seed system actors should be involved in considering regulatory options, and regularly monitor the benefits and costs arising from them.

Public funds are limited and decisions on funding seed system interventions should also consider opportunity costs. Ideally, opportunities for investing in variety development or local capacity building for seed production or processing would be considered alongside other more commonly funded options. Generating funds for public plant breeding through sale of early generation seed however is not appropriate in the present context of seed system development of staple cereals in the two countries, as it would simply increase seed costs for smallholder farmers.

Conclusions

The long-term nature and funding requirements for plant breeding research, especially variety development programs, is a critical issue. Without breeding innovations, seed systems cannot provide the expected advances, and

Plant breeding for improved food and nutrition security and food system resilience is a matter of public interest and not entirely coinciding with the interests of private breeding companies. While the latter can certainly have a role in contributing to this goal, their investment will necessarily be limited to crops and markets offering them economic opportunities — with complementary approaches and funding instruments also needed (see Section 6.2.2).

certainly not in a sustainable manner. It is thus essential to find longer-term funding options for variety creation in addition to short-term projects (see box and Section 6.2.2).

The large and increasing budgets for food and seed relief in both countries are indications for the failure of the entire seed system. Free seed distributions tend to have negative consequences on the overall development of the seed system. The elaboration of best practice recommendations for donors and governments involved in seed distributions and food-relief activities is urgently needed to support sustainable seed system developments and reduce the re-

currence of emergencies. These recommendations could include earmarking a percentage of expenditures toward investment in plant breeding research and related seed system development.

7.7 CONCLUDING REMARKS

Our joint learning, including that of the actors and workshop participants, is at one point in the spiral of learning (Nonaka and Takeuchi, 1995; see Figure 2). This learning must continue in order to advance the process of sustainable development of these seed systems.

Discussions directly with individuals and at both the Kenya and Mali workshops indicated how participating actors are interested in advancing and moving towards a “*collectively identified purpose*” (Banathy, 1997), in spite of the difficulties and tensions that may exist. However, this cannot happen without structured processes that bring these actors together to find solutions based on their perceptions of needs and options considering the socio-cultural and agroecological contexts in which the seed systems function.

Actors involved in our workshops made practical suggestions how such processes should be organized to achieve relevant results (Section 5.3.2). Supporting professional cooperation among actors towards self-driven change will very likely lead to more sustainable development of seed systems than short-term interventions into emerging seed markets or their strict regulation.

A key to sustainable seed system development appears to be the acknowledgement of diversity at all levels: agroecological and biological diversity, as well as diversity of actors, approaches and products. Rather *than excluding* actors and products from emerging seed markets, more inclusive innovation and development could be powerful, considering new actors and ‘loci’ of innovation capabilities⁵³ — and *strengthening their roles* through partnerships based on sound methodology and proven practice. Examples of this approach include actively looking for women as well as men as innovators and partners in research activities, and considering a broader range of organizations as research or development partners, e.g. associations of local food processors and traders. Furthermore, support for social as well as technical innovations (such as new varieties) could substantially enhance the innovation capacities of the individuals and groups involved. Establishing farmer networks for joint

⁵³ Suggestions made in the last three paragraphs partly rely on conceptual work of Cozzens and Sutz (2012) on innovation in informal settings, cited in a review of research on ‘inclusive innovation’ by Heeks *et al.* (2013), and adapted and modified by the authors for addressing seed system development.

variety testing, information exchange and decentralized seed production and dissemination are examples of interventions that are feasible and ongoing.

Lastly, seed system development in both Kenya and Mali could benefit from closer examinations of the roles of the new technologies, policies and formal organizations intended to support innovation. Strengthening efforts to analyze alternatives rather than prescribe or assume benefits of single options would help advance sustainable development of seed systems — and thereby improve the outcomes for all involved.

ACKNOWLEDGEMENTS

First, we are grateful to Prof Joachim von Braun und Dr Heike Baumüller (ZEF/PARI), for their guidance and encouragement in conducting this study in a way that provides a concrete basis for future actions by interested seed system actors, and for providing most valuable feedback at all stages of conducting this study.

The wholehearted support of Dr Lawrence Mose, the National PARI Coordinator for Kenya, including his provision of documents and contacts for KALRO specialists, is gratefully acknowledged. The interest and the 'opening of doors' by Dr Mose, Dr Felister Makini, KALRO Deputy Director Research, and Dr Joyce Maling'a, Director KARLO Food Crops Research Institute, gave this study a highly appreciated 'tailwind'. Likewise, the complete support by Dr Daouda Ballo, Mali National PARI Coordinator, as well as the interest shown by Dr Niang, IER Scientific Director, was most appreciated.

The contributions and sharing of all interviewees and workshop participants form the basis for this study and are greatly appreciated. Furthermore, this study could not have succeeded without the tireless and full effort of the field team members. Assistance with interviews and the stakeholder workshop provided by the field team in Kenya, Dr Simon Kimenju, Dr Charles Wasonga, Eric Murithi Kamui and Mugira Agostino and the field team in Mali, Gabriel Coulibaly, Samuel Guindo, Hamidou Guindo and Joel Tangara is equally appreciated. Particular appreciation is noted for Gabriel Coulibaly for facilitating the Mali workshop and guiding the heated debates in a positive direction.

Dr Joe de Vries, Dr Kapran Issoufou, and Dr George Bigirwa (all from AGRA), as well as Mamourou Sidibé (ICRISAT, Mali) and Dr Rokia Goldmann (GIZ, Mali), along with the members of our study team, all provided valuable feedback on a draft version of this study, which helped correct, improve and focus the final version. We are truly thankful for the time and effort they took to give comments despite tight time schedules.

The contributions of Dr Willmar Leiser and Stephan von Borstel in creating the maps and figures for this study, as well as the literature searches conducted by Esther Mieves, Research Assistant at DITSL, are also gratefully acknowledged. The financial arrangements facilitated by DITSL and the general support to this study provided by Dr Christian Hülsebusch (CEO), Prof Brigitte Kaufmann (director research) and administrative staff members of DITSL are also highly appreciated.

Finally, we are also most thankful for the 'home bases' provided by Anne Marie Ran, Salimata Keita and Pierre Gravel for our field work in Kenya and Mali.

ABOUT THE AUTHORS

Anja Christinck (PhD) is an Agricultural Social Scientists with specialization in communication and extension and transdisciplinary research methodology. As an independent consultant, she has worked together with plant breeders, farmers and genetic resources specialists on seed and biodiversity issues for more than 15 years, before joining the German Institute for Tropical and Subtropical Agriculture (DITSL) in 2013.

Contact: a.christinck@ditsl.org; Information: www.ditsl.org; www.seed4change.de.

Fred Rattunde (PhD) has worked as a cereal breeder for the past 30 years, working on oats, rye, pearl millet and sorghum. He was responsible for sorghum breeding in West Africa with ICRISAT for 18 years. During this time, he developed, jointly with national partners, the first sorghum hybrids based on local germplasm and, together with national scientists and farmer organizations, production capacity for hybrid seed. Since February 2016 he retired from ICRISAT and is working as a freelance consultant.

Contact: f.rattunde@gmail.com

Alpha Oumar Kergna works as quantitative economist in the department 'Ecofil' (Économie des Filières) of the Institut d'Économie Rurale (IER) in Bamako, Mali. He has conducted detailed adoption studies in the past on dryland cereals and other crops.

Contact: akergna@yahoo.fr

Wellington Mulinge (PhD) is economist and works as a Senior Principal Research Officer at the Socio-Economics and Policy Development Section at the headquarters of the Kenyan Agricultural and Livestock Research Organization (KALRO) in Kenya.

Contact: Wellington.Mulinge@kalro.org

Eva Weltzien worked on the improvement of dryland cereals in tropical and subtropical regions over the past 35 years, focusing on the effective use of sorghum, pearl millet and barley genetic resources for variety development and seed systems that best meet farmers' needs, in Syria, North-West India, Mali and other West African countries. She specialized in tools for appropriately targeting plant breeding research to priority production systems with farmers. Since February 2016 she retired from ICRISAT and is working as a freelance consultant.

Contact: eva.weltzien@gmail.com

ABOUT DITSL

The German Institute for Tropical and Subtropical Agriculture (DITSL) is an independent research institute in Witzenhausen, Germany, focusing on transdisciplinary research for development and social-ecological transformation in farming and food systems worldwide.

DITSL is specialized on sustainable land use and value creation in highly heterogeneous and variable environments. Using an actor-oriented approach, the perspectives, interests and capacities of societal actors are integrated to co-create contextual knowledge and options for actions that facilitate change in complex problem situations. Research methodologies include system analysis, knowledge management, knowledge integration and co-creation, gender analysis, multi-stakeholder processes, collaborative learning and action research.

Furthermore, DITSL generates decision support for policy and society as well as material for extension and academic, professional and extracurricular education and training programs (www.ditsl.org).

REFERENCES

- ABSF (2010). Sorghum Breeding in Sub-Saharan Africa: The success stories. African Biotechnology Stakeholders Forum (ABSF), Nairobi. Available at: <http://absfafrica.org/downloads/Sorghum%20Book%20Series.pdf> (12 April 2017).
- Adhikari, U., Neyadhashemi, A.P., and S.A. Woznicki (2015). Climate change and eastern Africa: a review of impact on major crops. *Food and Energy Security* 4 (2): 110-132.
- AgriExperience (2012). Kenya Seed Industry Study (KSIS). AgriExperience Ltd., Nairobi. Available at: <https://kenyamarkettrust.files.wordpress.com/2013/10/kenya-seed-industry-study.pdf> (22 July 2017).
- Albrecht, H. (ed.) (1994). *Einsicht als Agens des Handelns. Festschrift zum 80. Geburtstag von Erna Hruschka. Beratung und angewandte Psychologie.* Margraf Verlag, Weikersheim.
- Almekinders, C.J.M. (2000). The importance of the informal seed sector and its relation with the legislative framework. Paper presented at GTZ, Eschborn, 4-5 July 2000 (unpublished).
- Almekinders, C.J.M., Louwaars, N.P., and G.H. de Bruijn (1994). Local seed systems and their importance for an improved seed supply in developing countries. *Euphytica* 78(3): 207-216.
- Badstue, L.B. (2007). The role of trust in the acquisition of seed. *LEISA* 23 (2): 6-8.
- Badstue, L.B., Bellon, M.R., Juarez, X., Manuel, I., and A.M. Solano (2003). Social relations and seed transactions among small-scale maize farmers in the central valleys of Oaxaca, Mexico. Economics Working Paper No. 02/02. International Maize and Wheat Improvement Center (CIMMYT), Mexico. Available at: <http://repository.cimmyt.org/xmlui/bitstream/handle/10883/911/448295.pdf?sequence=4> (13 April 2017).
- Bänzinger, M., and M. Cooper (2001). Breeding for low input conditions and consequences for participatory plant breeding: Examples from tropical maize and wheat. *Euphytica* 122: 503-519.
- Banathy, B.A. (1997). *A Taste of Systemics. The Primer Project. First International Electronic Seminar on Wholeness.* International Society for the Systems Sciences (ISSS) and International Institute for Systemic Inquiry and Integration (IISII), December 1, 1996 to December 31, 1997. Available at: http://www.newciv.org/ISSS_Primer/ase04bb.html (March 19, 2017).
- Barro-Kondombo, C.P., vom Brocke, K., Chantereau, J., Sagnard, F., and J.D. Zongo (2008). Variabilité phénotypique des sorghos locaux de deux régions du Burkina-Faso: La Boucle du Mouhoun et le Centre-Ouest. *Cahiers d'Agriculture* 17: 107-113.
- Bellon, M.R. (2006). Crop research to benefit poor farmers in marginal areas of the developing world: a review of technical challenges and tools. *CAB Reviews: Perspectives in Agriculture, Veterinary Science, Nutrition and Natural Resources* No. 70. CABI, Wallingford.
- BMZ (2015). *A world without hunger is possible. Contributions of German development policy.* Federal Ministry for Economic Cooperation and Development (BMZ), Bonn/Berlin. Available at: https://www.bmz.de/en/publications/topics/poverty/Materialie242_welt_ohne_hunger.pdf (March 22, 2017).
- Capra, F., and P.L. Luisi (2014). *The Systems View of Life: A Unifying Vision.* Cambridge University Press, Cambridge.

- CFS (2012). Coming to Terms with Terminology. Food Security, Nutrition Security, Food Security and Nutrition, Food and Nutrition Security. Revised draft, July 25, 2012. Committee on World Food Security (CFS). Food and Agriculture Organization of the United Nations (FAO), Rome.
- Checkland, P. (1981). *Systems Thinking, Systems Practice*. John Wiley, Chichester.
- Christinck, A. (2002). "This seed is like ourselves" – a case study from Rajasthan, India, on the social aspects of biodiversity and farmers' management of pearl millet seed. *Series Communication and Extension* (47), Margraf Publishers, Weikersheim.
- Christinck, A., and E. Weltzien (2013). Plant breeding for nutrition-sensitive agriculture: an appraisal of developments in plant breeding. *Food Security* 5 (5): 693-707.
- Christinck, A., and M.W. Tvedt (2015). The UPOV Convention, Farmers' Rights and Human Rights. An integrated assessment of potentially conflicting legal frameworks. Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), Eschborn/Bonn. Available online at www.giz.de/fachexpertise/downloads/giz2015-en-upov-convention.pdf (March 22, 2017).
- Christinck, A., and B. Kaufmann (2018). Facilitating change. Methodologies for collaborative learning with stakeholders. Pp. 171-190. In: Padmanabhan, M. (ed.). *Transdisciplinarity for Sustainability: Collaboration, Innovation and Transformation*. Routledge, London.
- Christinck, A., E. Weltzien, and V. Hoffmann (2005). Setting Breeding Objectives and Developing Seed Systems with Farmers. *A Handbook for Practical Use in Participatory Plant Breeding Projects*. Margraf Publishers, Weikersheim and Technical Centre for Agricultural and Rural Cooperation (CTA), Wageningen.
- Christinck, A., Diarra, M., and G. Horneber (2014). Innovations in seed systems: Lessons from the CCRP-funded Project 'Sustaining Farmer-Managed Seed Initiatives in Mali, Niger, and Burkina Faso'. The McKnight Foundation, Minneapolis. Available at www.mcknight.org/system/asset/document/850/original/CCRP_SeedSystems_Nov2014.pdf (March 20, 2017).
- Christinck, A., Weltzien, E., Rattunde, F., and J. Ashby (2017). Gender Differentiation of Farmer Preferences for Varietal Traits in Crop Improvement: Evidence and Issues. Working Paper No. 2. CGIAR Gender and Agriculture Research Network; CGIAR System Management Office and International Center for Tropical Agriculture (CIAT), Cali. Available at: <https://library.cgiar.org/handle/10947/4660> (25 July 2017).
- CIMMYT (2015). Maize in Mali: Successes and Opportunities. DT Maize No. 4. A Quarterly Bulletin of the Drought Tolerant Maize for Africa Project. International Maize and Wheat Improvement Center (CIMMYT), Nairobi. Available at: http://dtma.cimmyt.org/index.php/publications/doc_view/193-dt-maize-a-quarterly-bulleting-of-the-drought-tolerant-maize-for-africa-project-vol-4-no-1-march-2015 (12 April 2017).
- Context Network (2016). Kenya Early Generation Seed Study Country Report. United States Agency for International Development (USAID), Washington. Available at: <https://www.africleadftf.org/wp-content/uploads/2016/09/Kenya-EGS-Study-Final-Report.pdf> (4 November 2017).
- Coulibaly, A. (2003). Mali. Country Pasture and Forage Resources Profile. Food and Agriculture Organization of the United Nations (FAO), Rome. Available at: <http://www.fao.org/ag/agp/agpc/doc/coun-prof/Mali/mali.htm#2.%20SOILS%20AND> (22 March 2017).
- Coulibaly, H., Bazile, D., and A. Sidibé (2014). Modelling Seed System Networks in Mali to Improve Farmers Seed Supply. *Sustainable Agriculture Research* 3 (4): 18-32.

References

- CRS/Mali and Partners (2006). Seed System Security Assessment (SSSA) Douentza, northern Mali. Catholic Relief Services (CRS) Mali, Bamako. Available at: http://pdf.usaid.gov/pdf_docs/pbaaa632.pdf (4 November 2017).
- Dagnoko, S. (no year). Mali: Development of Mali's Seed Industry — PSAO/WASP Contribution. West and Central African Council for Agricultural Research and Development (CORAF/WECARD). Available at: <http://coraf.org/wasp-learningevent/fichiers/mali.pdf> (17 November 2017).
- Dalberg (2012). Catalyzing Smallholder Agricultural Finance. Dalberg Global Development Advisors, New York.
- Daou, O. (2016). Mali: un taux de pauvreté estimé à 47,2% in 2015. Available at: <http://maliactu.net/mali-mali-un-taux-de-pauvrete-estime-a-472-en-2015/> (25 April 2017).
- Delêtre, M., McKey, D.B., and T.R. Hodkinson (2011). Marriage exchanges, seed exchanges, and the dynamics of manioc diversity. *Proceedings of the National Academy of Sciences of the United States of America (PNAS)* 108 (45): 18249-18254.
- Deu, M., Weltzien, E., Calatayud, C., Traoré, Y., Bazile, D., Gozé, E., Trouche, G., and K. vom Brocke (2014). How an improved sorghum variety evolves in a traditional seed system in Mali: Effects of farmers' practices on the maintenance of phenotype and genetic composition. *Field Crops Research* 167: 131-142.
- Dhakal, S. (2013). Seed Producer Organizations of Farmers: An Experience of Western Terai, Nepal. *Agronomy Journal of Nepal* 2013 (3): 156-167.
- Diallo, M. (2009). A Diagnostic Study of Farmers Seed Quality and Variety Preference in Southern Mali. PhD Thesis (unpublished). Department of Crops and Soils Science (CSS), Michigan State University (MSU), East Lansing.
- Diallo, M.G., and W.S. de Boef (2012). Mali Seed Sector Assessment. ISSD Breifing Note, September 2012. Centre for Development Innovation, Wageningen University, Wageningen. Available at: http://www.issd-seed.org/sites/default/files/resource/mali_seed_sector_assessment_2012_1.pdf (17 November 2017).
- Dohr, D., Kumria, P., and J. Metzger (2015). Saatgut und Sozialsystem. Gender, Monetarisierung und bäuerliche Praktiken der Ernährungssicherung in Namibia und Tansania. Reihe: Spektrum. Berliner Reihe zu Gesellschaft, Wirtschaft und Politik in Entwicklungsländern No. 112. LIT Verlag, Berlin.
- FAO (2004). Seed multiplication by resource-limited farmers. Plant Production and Protection Paper No. 180. Food and Agriculture Organization of the United Nations (FAO), Rome.
- FAO (2005). Irrigation in Africa in figures: AQUASTAT Survey 2005. Food and Agriculture Organization of the United Nations (FAO), Rome. Available at: http://www.fao.org/fileadmin/user_upload/drought/docs/kenya_cp.pdf (24 April 2017).
- FAO (2006). Quality Declared Seed System. FAO Plant Production and Protection Paper No. 185. Food and Agriculture Organization of the United Nations (FAO), Rome.
- FAO (2014). Seed Security Assessment of the South-Eastern Livelihood Zone of Kenya. Food and Agriculture Organization of the United Nations (FAO), Rome. Available at: http://www.fao.org/fileadmin/user_upload/food-security-capacity-building/docs/Seeds/SSA/FAO-SSA_ReportKenya2014.pdf (4 November 2017).
- FAO (2017). Seed systems. FAO web site "Seeds and Plant Genetic Resources". Available at http://www.fao.org/agriculture/crops/core-themes/theme/seeds-pgr/seed_sys/en/ (20 March 2017).
- Galletta, A. (2013). Mastering the Semi-Structured Interview and Beyond. From Research Design to Analysis and Publication. New York University Press, New York/London.

- Gatzweiler, F.W., and J. von Braun (2016). Innovation for Marginalized Smallholder Farmers and Development: An Overview and Implications for Policy and Research. Pp. 1-22. In: Gatzweiler, F.W., and J. von Braun (eds.). Technological and Institutional Innovations for Marginalized Smallholders in Agricultural Development. Springer International Publishing, Basel.
- Gemenet, D.C., Leiser, W.L., Beggi, F., Herrmann, L.H., Vadez, V., Rattunde, H.F.W., Weltzien, E., Hash, C.T., Buerkert, A., and B.I.G. Haussmann (2016). Overcoming Phosphorus Deficiency in West African Pearl Millet and Sorghum Production Systems: Promising Options for Crop Improvement. *Frontiers in Plant Science* 7: 1398.
- Golafshani, N. (2003). Understanding Reliability and Validity in Qualitative Research. *The Qualitative Report* (TQR) 8 (4): 597-606. Available at: <http://nsuworks.nova.edu/cgi/viewcontent.cgi?article=1870&context=tqr> (22 November 2017).
- Government of Kenya (2008). The Vision 2030: A Competitive and Prosperous Kenya. Ministry of Planning and National Development, Nairobi. Available at: <http://www.vision2030.go.ke/> (27 July 2017).
- Government of Kenya (2009). Biosafety Act. Available at: <http://extwprlegs1.fao.org/docs/pdf/ken89675.pdf> (27 July 2017).
- Government of Kenya (2010a). Agricultural Sector Development Strategy (ASDS) (2010-2020). Agricultural Sector Coordinating Unit (ASCU), Nairobi.
- Government of Kenya (2010b) National Seed Policy. Ministry of Agriculture, Nairobi. Available at: <https://www.stak.or.ke/wp-content/uploads/2016/08/Kenya-Seed-Policy-2010.pdf> (27 July 2017).
- Government of Kenya (2011). National Food and Nutrition Security Policy. Agricultural Sector Coordination Unit (ASCU), Nairobi.
- Government of Kenya (2012a). Seeds and Plant Varieties Act. Available at: <http://www.kenya-law.org/lex/actview.xql?actid=CAP.%20326> (27 July 2017).
- Government of Kenya (2012b). Plant protection Act. Available at: <http://extwprlegs1.fao.org/docs/pdf/ken18403.pdf> (22 July 2017).
- Government of Kenya (2012c). National Agricultural Sector Extension Strategy (NASEP). Agricultural Sector Coordination Unit (ASCU), Nairobi. Available at: <https://www.kenyamarkets.org/wp-content/uploads/2016/06/National-Agricultural-Sector-Extension-2012.pdf> (27 July 2017).
- Government of Kenya (2012d). National Agricultural Research System (NARS) Policy. Agricultural Sector Coordinating Unit (ASCU), Nairobi.
- Government of Kenya (2013). Crops Act. Available at: <http://www.kenya-law.org/lex/actview.xql?actid=No.%2016%20of%202013> (22 July 2017).
- Government of Kenya (2015). Agricultural Policy. Food: Our Health, Wealth and Security. Ministry of Agriculture, Livestock and Fisheries, Nairobi.
- Government of Kenya (2016). The Seed and Plant Varieties Act, CAP 326. Legal Notice No. 215. Kenya Gazette Supplement No. 202. Legislative Supplement No. 79. The National Assembly, Nairobi.
- Hart, K. (1973). Informal Income Opportunities and Urban Employment in Ghana. *The Journal of Modern African Studies* 11 (1): 61-89.

References

- Hart, K. (1985). The informal economy. *Cambridge Journal of Anthropology* 10 (2): 54-58.
- Harwood, J. (2012). *Europe's Green Revolution and Other's Since. The rise and fall of peasant-friendly plant breeding.* Routledge, London.
- Haugen, H.M. (2015). Inappropriate Processes and Unbalanced Outcomes: Plant Variety Protection in Africa Goes Beyond Requirements of UPOV 1991. *Journal of World Intellectual Property* 18 (5): 196-216.
- Hausmann, B.I.G., Rattunde, H.F.W., Weltzien-Rattunde, E., Traoré, P.S.C., vom Brocke, K., and H.K. Parzies (2012). Breeding Strategies for Adaptation of Pearl Millet and Sorghum to Climate Variability and Change in West Africa. *Journal of Agronomy and Crop Science* 198: 327-339.
- Hebinck, P., den Ouden, J., and G. Verschoor (2001). Past, present and future: Long's actor-oriented approach at the interface. Pp. 1-19. In: Hebinck, P. and G. Verschoor (eds.). *Resonances and dissonances in development: actors, networks and cultural repertoires.* Royal van Gorcum, Assen.
- Homabay County Government (2013). Homabay County Integrated Development Plan, 2013-2017. Available at: http://www.homabay.go.ke/wp-content/uploads/2016/01/CIDP-DOCUMENT-HOMA-BAY-COUNTY-GOV-ERNMENT.OCT_2013.pdf (25 April 2017).
- Hoffmann, V., Probst, K., and A. Christinck (2007). Farmers and researchers: How can collaborative advantages be created in participatory research and technology development? *Agriculture and Human Values* 24: 355-368.
- ISSD Africa (2017). Financing Seed Business. Synthesis Paper. Wageningen Centre of Development Innovation (CDI), Wageningen and Royal Tropical Institute (KIT), Amsterdam. Available at http://www.issd-seed.org/sites/default/files/case/issd_africa_twg1_sp3_seed_finance_170412.pdf (22 November 2017).
- Jarvis, D., Hodgkin, T., Sthapit, B.R., Fadda, C., and I. Lopez-Noriega (2011). An Heuristic Framework for Identifying Multiple Ways of Supporting the Conservation and Use of Traditional Crop Varieties within the Agricultural Production System. *Critical Reviews in Plant Sciences* 30: 125-176.
- Jones, K. (2014): Emerging seed markets, substantive seed economies and integrated seed systems in West Africa: A mixed method analysis. PhD thesis in Rural Sociology and International Agriculture and Development. Department of Agri-cultural Economics, Sociology, and Education. Pennsylvania State University. Available at <https://etda.libraries.psu.edu/paper/21110/21030> (22 April 2017).
- Kante, M., Rattunde, H.F.W., W.L., Leiser, Nebié, B., Diallo, B., Diallo, A., Touré, A.O., Weltzien, E., and B.I.G. Hausmann (2017). Can Tall Guinea-Race Sorghum Hybrids Deliver Yield Advantage to Smallholder Farmers in West and Central Africa? *Crop Science* 57: 833.
- Karanja, S. (2015). Kenya ranked sixth on extreme poverty index. *Daily Nation*, February 18, 2015. Available at: <http://www.nation.co.ke/news/Poverty-Africa-Index-Kenya-Inequality/1056-2628224-vqlg4v/index.html> (22 April 2017).
- Karingu, A.W., and P.K. Ngugi (2013). Determinants of the infiltration of counterfeit agro-based products in Kenya: A case of suppliers in Nairobi. *International Journal of Human Resources and Procurement* 1 (5): 1-14.
- Kater, L., Dicko, I., and I. Dembele (2000). The dynamics of irrigated rice farming in Mali. *Managing Africa's Soils* No.12. International Institute for Environment and Development (IIED), London.
- KEPHIS (2012). *KEPHIS Annual Report & Financial Statement 2012.* Kenya Plant Health Inspectorate Service (KEPHIS), Nairobi.

- KEPHIS (2016). KEPHIS Annual Report & Financial Statement 2016. Kenya Plant Health Inspectorate Service (KEPHIS), Nairobi.
- Kunz, P., Hurter, U., and J. Wirz (2015). Ein Kulturpflanzen-Promille für das Gemeingut Saatgut? Jahresbericht Winter 2015. Getreidezüchtung Peter Kunz – Verein für Kulturpflanzenentwicklung, Feldbach.
- Leiser, W.L., Rattunde, H.F.W., Piepho, H.-P.; Weltzien, E., Diallo, A., Melchinger, A.E., Parzies, H.K., and B.I.G. Haussmann (2012). Selection Strategy for Sorghum Targeting Phosphorus-limited Environments in West Africa: Analysis of Multi-environment Experiments. *Crop Science* 52: 2517–2527.
- Lelea, M.A., Roba, G.M., Christinck, A., and B.A. Kaufmann (2014). Methodologies for Stakeholder Analysis — for application in transdisciplinary research projects focusing on actors in food supply chains. Deutsches Institut für tropische und subtropische Landwirtschaft (DITSL), Witzenhausen, Germany. Available at: [http://reload-globe.net/cms/attachments/article/56/Lelea_et_al_\(2014\)_StakeholderGuide_final_web.pdf](http://reload-globe.net/cms/attachments/article/56/Lelea_et_al_(2014)_StakeholderGuide_final_web.pdf) (13 April 2017).
- Long, N. (2000). Exploring Local/Global Transformations: A View from Anthropology. Pp. 184-201. In: Arce, A. and N. Long (eds.). *Anthropology, Development and Modernities. Exploring Discourses, Counter-Tendencies and Violence*. Routledge, London.
- Long, N. (2001). *Development Sociology: Actor Perspectives*. Routledge, London/New York.
- Masaki, K. (2007). Theoretical and Conceptual Frameworks: Power, Participation, and Policy. Pp. 17-41. In: Masaki, K. (ed.). *Power, Participation, and Policy: The “Emancipatory” Evolution of the “Elite-Controlled” Policy Process*. Lexington Books, Plymouth.
- McDermott, J., Johnson, N., Kadiyala, S., Kennedy G., and A.J. Wyatt (2015). Agricultural research for nutrition outcomes – rethinking the agenda. *Food Security* 7 (3): 593-607.
- McGuire, S., and L. Sperling (2011). The links between food security and seed security: facts and fiction that guide response. *Development in Practice* 21 (4-5): 493-508.
- McGuire, S., and L. Sperling (2016). Seed systems smallholder farmers use. *Food Security* 8 (1): 179-195.
- MFW4A (2012). Policy Brief on Agricultural Finance in Africa. Making Finance Work For Africa (MFW4A) Partnership. African Development Bank, Tunis. Available at <https://www.mfw4a.org/nc/knowledge-center/resources/documents/documents-details/file/policy-brief-on-agricultural-finance-in-africa.html?dl=1&cHash=5a07514f6fac68c5eca928f7a0996180> (22 November 2017).
- Ministère de l’Agriculture (2009). National Strategy for the Development of Rice Growing. République du Mali, Bamako. Available at: https://www.jica.go.jp/english/our_work/thematic_issues/agricultural/pdf/mali_en.pdf (28 July 2017).
- Ministère de l’Agriculture (2016a). Annuaire Statistique 2015 du Secteur Développement Rural. République du Mali, Bamako. Available at: http://mali.countrystat.org/fileadmin/user_upload/countrystat_fenix/congo/docs/Annuaire Statistique SDR 2015 .pdf (27 July 2017).
- Ministère de l’Agriculture (2016b). Statistiques des résultats d’analyses qualitatives des lots de semences de la campagne agricole 2015-2016. Laboratoire LABOSEM, Bamako.
- Ministère du Développement Rural (2014). Annuaire statistique 2013, Secteur du Développement Rural. République du Mali, Bamako. Available at: http://mali.countrystat.org/fileadmin/user_upload/countrystat_fenix/congo/docs/Annuaire%20Statistique%202013_VF.pdf (27 July 2017).

References

- Misiko, M., Almekinders, C., Barker, I., Borus, D., Oggema, J., and J. Mukalama (2011). Kenya: A Company, a Co-operative and a Family. Pp. 142-155. In: Van Mele *et al.* (eds.). African Seed Enterprises: Sowing the Seeds of Food Security. CAB International, Wallingford.
- MoALF (2016). Economic Review of Agriculture (ERA) 2015. Kenyan Ministry of Agriculture, Livestock and Fisheries, Nairobi. Available at: http://www.kilimo.go.ke/wp-content/uploads/2015/10/Economic-Review-of-Agriculture_2015-6.pdf (22.4.2017).
- Moschitz, H., Roep, D., Brunori, G., and T. Tisenkopfs (2015). Learning and Innovation Networks for Sustainable Agriculture: Processes of Co-evolution, Joint Reflection and Facilitation. *Journal of Agricultural Education and Extension* 21 (1): 1-11.
- Mucioki, M., Johns, T., Muriithi, C., and G. Hickey (2016a). The Influence of Gender Roles And Human Migrations on the Distribution of Crop Biodiversity in Tharaka, Kenya. *Journal of Ethnobiology* 36: 172-191.
- Mucioki, M., Hickey, G.M., Muhammad, L., and T. Johns (2016b). Supporting farmer participation in formal seed systems: lessons from Tharaka, Kenya. *Development in Practice* 26: 137-148.
- Mucioki, M., Johns, T., and S.K. Mucioki (2016c). Gendered Food and Seed Producing Traditions for Pearl Millet (*Pennisetum glaucum*) and Sorghum (*Sorghum bicolor*) in Tharaka-Nithi County, Kenya. Pp. 73–87. In: Brownhill, L. *et al.* (eds.). Food Security, Gender and Resilience: Improving Smallholder and Subsistence Farming. Earthscan from Routledge, Oxford.
- Mueller, S.M., and T.J. Vyn (2016). Maize Plant Resilience to N Stress and Post-silking N Capacity Changes over Time: A Review. *Frontiers in Plant Science* 7: 53.
- Narayanasami, N. (2009). Participatory Rural Appraisal: Principles, Methods and Application. SAGE Publications, New Delhi.
- Nonaka, I., and H. Takeuchi (1995). The knowledge creating company. How Japanese companies create the dynamics of innovation. Oxford University Press, London/New York.
- Pingali, P. (2015). Agricultural policy and nutrition outcomes – getting beyond the preoccupation with staple grains. *Food Security* 7 (3): 583-591.
- Pray, C.E., and B. Ramaswami (2001). Liberalization of the Indian Seed Industry: competition, research and impact on farmers. *The International Food and Agribusiness Review* 2: 407-420.
- Pray, C.E., Ribeiro, S., Mueller, R.A.E., and P. Parthasarathy Rao (1991). Private Research and Public Benefit: The Private Seed Industry for Sorghum and Pearl Millet in India. *Research Policy* 20: 315-324.
- Rattunde, H.F.W., Weltzien, E., Diallo, B., Diallo, A.G., Sidibe, M., Touré, A.O., Rathore, A., Das, R.R., Leiser, W.L., and A. Touré (2013). Yield of photoperiod-sensitive sorghum hybrids based on guinea-race germplasm under farmers' field conditions in Mali. *Crop Science* 53 (6): 2454-2456.
- Rattunde, H.F.W., Michel, S., Leiser, W.L., Piepho, H.P., Diallo, C., vom Brocke, K., Haussmann, B.I.G., and E. Weltzien (2016). Farmer participatory early-generation yield testing of sorghum in West Africa: Possibilities to optimize genetic gains for yield in farmers' fields. *Crop Science* 56 (5): 2493-2505.
- Rattunde, F., Sidibé, M., Diallo, B., van den Broek, E., Somé, H., vom Brocke, K., Diallo, A., Nebie, B., Touré, A., Isaacs, K., and E. Weltzien (2017). Involving women farmers in variety evaluations of a “men’s crop”: Consequences for the sorghum breeding strategy and farmer empowerment in Mali. In: Tufan, H.A. *et al.* (eds.). State of the Knowledge for Gender-Responsive Breeding: Case Studies for Practitioners. CGIAR Gender and Breeding Initiative Working Document. International Potato Center (CIP), Lima.

- Région de Mopti (2006). Synthèse des plans de sécurité alimentaire des communes du cercle de Mopti, 2006-2010. Available at: http://fsg.afre.msu.edu/mali_fd_strtgy/plans/mopti/mopti/psa_synthese_cer-cle_mopti.pdf (23 March 2017).
- Région de Mopti (2011). Étude sur les bassins de production des spéculations céréalières de la région de Mopti. Available at: http://fsg.afre.msu.edu/promisam_2/reconnaissance_bassin_Mopti.pdf (25 March 2017).
- Région de Ségou (2011). Rapport provisoire de l'étude portant sur la reconnaissance rapide des axes et circuits de commercialisation de céréales au Mali. Available at: http://fsg.afre.msu.edu/promisam_2/reconnaissance_bassin_Ségou.pdf (24 March 2017).
- Région de Sikasso (2007). Plan de Sécurité Alimentaire: Commune Urbaine de Sikasso. Available at: http://fsg.afre.msu.edu/mali_fd_strtgy/plans/sikasso/sikasso/psa_sikasso.pdf (23 March 2017).
- Remington, T., Maroko, J., Walsh, S., Omanga, P., and E. Charles (2002). Getting off the seeds-and-tools treadmill with CRS seed vouchers and fairs. *Disasters* 26 (4): 316-328.
- Restrepo, M.J., Lelea, M.A., Christinck, A., Hülsebusch, C., and B.A. Kaufmann (2014). Collaborative learning for fostering change in complex social-ecological systems: A transdisciplinary perspective on food and farming systems. *Knowledge Management for Development Journal* 10 (3): 38-59.
- Rooney, W. (2004). Sorghum Improvement — Integrating Traditional and New Technology to Produce Improved Genotypes. *Advances in Agronomy* 83: 37-109.
- Santilli, J. (2006). Cultural Heritage and Collective Intellectual Property Rights. *IK Notes*, No. 95. The World Bank, Washington DC.
- Setimela P.S., Badu-Apraku, B., and W. Mwangi. (2009). Variety Testing and Release Approaches in DTMA Project Countries in Sub-Saharan Africa. International Maize and Wheat Improvement Center (CIMMYT), Harare.
- Siart, S. (2008). Strengthening local seed systems: Options for enhancing diffusion of varietal diversity of sorghum in Southern Mali. *Series Communication and Extension* (85). Margraf Publishers, Weikersheim.
- Sikinyi, E.O. (2010). Baseline study/Survey report on the seed sector in Kenya. Seed Trade Association of Kenya (STAK), Nairobi. Available at: <http://afsta.org/wp-content/uploads/documents/KENYA%20SEED%20SEC-TOR%20BASELINE%20STUDY.pdf> (12 April 2017).
- Sisay, D.T., Verhees, F.J.H.M., and H.C.M. van Trijp (2017). Seed producer cooperatives in the Ethiopian seed sector and their role in seed supply improvement: A review. *Journal of Crop Improvement* 31 (3): 323-355.
- Smale, M., and J. Olwande (2014). Demand for maize hybrids and hybrid change on smallholder farms in Kenya. *Agricultural Economics* 45 (4): 409-420.
- Smale, M., Kergna, A., and L. Diakitè (2016). Impact Assessment Report No. 2. An Economic Assessment of Sorghum Improvement in Mali. International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru.
- Sperling, L. (2001). Emergency Seed Aid in Kenya. A Case Study of Lessons Learnt. Occasional Publications Series No. 34. International Center for Tropical Agriculture (CIAT), Cali.
- Sperling, L. (2008). When disaster strikes. A guide for assessing seed security. International Center for Tropical Agriculture (CIAT), Cali, Colombia.

References

- Sperling, L., and D. Cooper (2003). Understanding seed systems and seed security. Improving the effectiveness and sustainability of seed relief. Proceedings of a stakeholders' workshop, Rome, May 26-28, 2003. FAO, Rome.
- Sperling, L., Remington, T., Haugen, J.M., and S. Nagoda (eds.) (2004). Addressing seed security in disaster response: Linking relief with development. International Center for Tropical Agriculture (CIAT), Cali.
- Sperling, L., Cooper, H.D., and T. Remington (2008). Moving towards more effective seed aid. *Journal of Development Studies* 44 (4): 586-612.
- Tharaka Nithi County Government (2013). Tharaka Nithi County Integrated Development Plan, 2013-2017. Available at: <https://cog.go.ke/images/stories/CIDPs/TharakaNithi.pdf> (25 April 2017).
- Thijssen, M.H., Bishaw, Z., Beshir, A., and W.S. de Boef (2008). Farmers, seeds and varieties. Supporting informal seed supply in Ethiopia. Wageningen International, Programme for Capacity Development and Institutional Change. Wageningen University and Research Centre, Wageningen.
- Tjernström, E., Clavijo, J., Bhakta, M., Lybbert, T., Pincuss, L., Singh, J. and C.E. Vallejos (2017). When Intentions Matter – Identifying the Prevalence and Source of Poor-Quality Inputs in Western Kenya. Working paper (unpublished) based on results presented at the 11th Conference of the International Consortium on Applied Bioeconomy Research (ICABR) "Bioeconomy in Transition: New Tools and New Actors", May 30-June 2, 2017 at Berkeley, California.
- Trans Nzoia County Government (2013). Trans Nzoia County Integrated Development Plan, 2013-2017. Available at: <https://cog.go.ke/images/stories/CIDPs/TransNzoia.pdf> (25 April 2017).
- UNCDP (2016). List of Least Developed Countries (as of May 2016). United Nations Committee for Development Policy (UNCDP), New York. Available at: http://www.un.org/en/development/desa/policy/cdp/ldc/ldc_list.pdf (25 April 2017).
- UNDP (2016a). Human Development Report 2016. Briefing note for countries on the 2016 Human Development Report: Kenya. United Nations Development Program (UNDP), New York.
- UNDP (2016b). Human Development Report 2016. Briefing note for countries on the 2016 Human Development Report: Mali. United Nations Development Program (UNDP), New York.
- USAID/OFDA (2011). Seed System Security Assessment Eastern and Coastal Kenya. United States Agency for International Development (USAID) and United States Office of Foreign Disaster Assistance (OFDA), Washington.
- USDA (2017). GAIN Report. United States Department of Agriculture (USDA), Foreign Agricultural Service, Dakar. Available at: <https://gain.fas.usda.gov/Recent%20GAIN%20Publications/Grain%20and%20Feed%20Annual%20Dakar%20Senegal%204-11-2017.pdf> (27 July 2017).
- Van Mele, P., Bentley, J.W., and R.G. Guéi (eds.) (2011). African Seed Enterprises. Sowing the Seeds of Food Security. CAB International, Wallingford.
- Wennink, B., Togola, B., and T. Hilhorst (2012). Bâtir l'entrepreneuriat paysan au Mali. Les enseignements tirés des coopératives agricoles appuyées par le programme de Développement Economique Rural de la Région de Koulikoro. Royal Tropical Institute (KIT), Amsterdam.
- Weltzien, E., and A. Christinck (2009). Methodologies for priority setting in plant breeding programs. Pp. 75-105. In: Ceccarelli, S. *et al.* (eds.). Plant breeding and farmer participation. FAO, Rome.

ANNEX

- A. Complete list of interviews conducted in Kenya
- B. Complete list of interviews conducted in Mali
- C. List of workshop participants in Kenya
- D. List of workshop participants in Mali
- E. Specific suggestions for seed system enhancement by crop and country

A. COMPLETE LIST OF INTERVIEWS CONDUCTED IN KENYA, 7-24 FEBRUARY 2017

Listed are names of those interviewed, their organization and actor category, location, interviewer (see explanation below), numbers of male (M) and female (F) interviewees, and workshop participants (P).

Name	Organization	Actor Category	Date	Location	County	Int*	M	F	P
Simon Mitambo	African Biodiversity Network	Other	12-Feb	Kathwana	Tharaka Nithi	FR, SK, EM	1		1
Francis Mureithi	NDMA (Nat. Drought Mng. Authority)	Extension	13-Feb	Marimanti	Tharaka Nithi	FR, SK, EM	1		
Hussein Idhoro	NDMA (Nat. Drought Mng. Authority)	Extension	13-Feb	Marimanti	Tharaka Nithi	FR, SK, EM	1		
Rachel G., Luke G., Duncan G.	MOALF (Min of Agriculture Livestock and Fisheries)	Extension	13-Feb	Marimanti	Tharaka Nithi	FR, SK, EM	2	1	
Nicholas Kimathi	RIDEP (Rural Initiative Dev Prog)	Other	13-Feb	Marimanti	Tharaka Nithi	FR, SK, EM	1		
Shadrack Njeru	Ma Banda Chemist	Seed Seller	13-Feb	Marimanti	Tharaka Nithi	FR, SK, EM	1		
Lucy M Peninah G.	Marimanti Bee Women Group	Farmer	13-Feb	Marimanti	Tharaka Nithi	FR, SK, EM		2	
Sarah Kathure	Kairanya Agrodealers	Seed Seller	14-Feb	Marimanti	Tharaka Nithi	SK		1	
Edward M., Jacob M., Jackson N.	Rwatha Together, Tharaka Cereal Growers Association	Farmer	14-Feb	Gatunga	Tharaka Nithi	SK	3		
Bernard N, Samuel K, Jeremy M	Tharaka Poultry CBO	Grain Trader	14-Feb	Mukothima	Tharaka Nithi	SK	3		1
Christine, Francesca, Penninah	RIDEP (Rural Initiative Development Program)	Farmer	14-Feb	Gatunga	Tharaka Nithi	FR		3	
Stella K, Flora C		Farmer	14-Feb	Mukothima	Tharaka Nithi	FR, SK		2	
Dorothy Gituura		Farmer	15-Feb	Nkondi	Tharaka Nithi	FR		1	
Joshua, Julius, James		Farmer	15-Feb	Nkondi	Tharaka Nithi	FR	3		
Janet Kabea		Farmer	15-Feb	Nkondi	Tharaka Nithi	FR		1	
Janet M, Tabitha G		Farmer	15-Feb	Nkondi	Tharaka Nithi	FR, SK		2	
Allan Mutegi	Cape Corner Farmer Agrovet	Seed Seller	15-Feb	Nkondi	Tharaka Nithi	SK	1		1
Josephine K, Catherine K		Farmer	15-Feb	Nkondi	Tharaka Nithi	SK		2	

Name	Organization	Actor Category	Date	Location	County	Int*	M	F	P
George Mwithi		Farmer	15-Feb	Nkondi	Tharaka Nithi	SK	1		
John Bosco Mureithi	Ministry of Agriculture	Extension	16-Feb	Marimonti	Tharaka Nithi	FR, SK, EM	1		
Paulina, Antonia		Farmer	16-Feb	Tunyai	Tharaka Nithi	FR		2	
Pakasio Njeru		Seed Producer	16-Feb	Tunyai	Tharaka Nithi	SK	1		
Benson N, Francis N		Farmer	16-Feb	Tunyai	Tharaka Nithi	SK	2		
Susan K Kamau	Susan & Sons Stores	Grain Trader	16-Feb	Tunyai	Tharaka Nithi	SK		1	
Martin M, James M	Mandeleo B Chicken	Farmer	16-Feb	Nkorini	Tharaka Nithi	FR, SK	2		1
Mary G N, Catherine M	Maendeleo B Chicken Group	Farmer	16-Feb	Nkarini	Tharaka Nithi	SK		2	
Florence Kanake		Farmer	17-Feb	Kamwebu, Twanhanju	Tharaka Nithi	FR, EM		1	
Michael, Monika, Harriet	Twathanju Self Help Group (older members)	Farmer	17-Feb	Twanhanju, Tharaka North	Tharaka Nithi	FR, SK, EM	1	4	
Robina K Kaibiru		Extension	17-Feb	Kathangacini	Tharaka Nithi	FR		1	
Regina K, Lucy K, Monicah K		Farmer	17-Feb	Kathangacini	Tharaka Nithi	SK		3	
Grace K, Lydia K, Agnes K	Twathanju Self Help Group (younger members)	Farmer	17-Feb	Kathangacini	Tharaka Nithi	SK		3	
Robina Karimi Kaibiru	KCEP	Farmer - Extension	17-Feb	Kathangacini	Tharaka Nithi	SK	1	11	1
John M Francis		Grain Trader	17-Feb	Nkondi	Tharaka Nithi	SK	1		
Simon Maingi	Paramount Chief	Farmer	18-Feb	Kajuki	Tharaka Nithi	FR	1		
John Kiura Mutua		Farmer	18-Feb	Kajuki	Tharaka Nithi	SK	1		
Rudia Kabori		Farmer	18-Feb	Kamugaa (near Kajuki)	Tharaka Nithi	FR, EM		1	
Bancy Nyaga		Grain Trader	18-Feb	Ishiara	Tharaka Nithi	FR, SK		1	
John Mucie Mdagi	Caritas Meru	Other	18-Feb	Kathangacini	Tharaka Nithi	SK	1		
Rosebela Sifuna		Farmer	14-Feb	Baraton Village	Trans Nzoia	CW		1	
Reuben Webala		Farmer	14-Feb	Baraton Village	Trans Nzoia	CW	1		
George Cheruyiot	Kachibora	Farmer	11-Feb	Kachibora	Trans Nzoia	EWR, CW	2	1	

Name	Organization	Actor Category	Date	Location	County	Int*	M	F	P
Dorcas G, Michael K	Kaplamai Farmers Group	Farmer - Other	11-Feb	Kaplamai	Trans Nzoia	EWR, CW	14	4	1
Edna W, Paul L	Farmers Group	Farmer - Other	11-Feb	Kaplemur TAC	Trans Nzoia	EWR, CW	2	4	
Jane Luvaga		Farmer	11-Feb	Kaplemur TAC	Trans Nzoia	EWR, CW		1	
Tom Nyairo	SeedCo	Seed Co.	10-Feb	Kiminini/Babiton	Trans Nzoia	EWR, CW	1		
Irene Keter	Kipkeikei Agrover	Seed Seller	11-Feb	Kipkeikei	Trans Nzoia	EWR, CW		1	
Kipkeikei	Kipkeikei farmers group	Farmer - Other	11-Feb	Kipkeikei	Trans Nzoia	EWR, CW	29	2	
Joyce Malinga	KALRO Food Crops Research Institute	Other	9-Feb	Kitale	Trans Nzoia	EWR, CW	5	2	1
Paul Lelei, Too Dorcas	Agrodealers Association	Seed Seller	9-Feb	Kitale	Trans Nzoia	EWR, CW	1	1	1
Nimrod Kipchumba	Agric Dev Corp (ADC)	Seed Company	10-Feb	Kitale	Trans Nzoia	EWR, CW	1		
Humphrey Kiboi	Kenya Farmers Assoc (KFA)	Seed Seller	10-Feb	Kitale	Trans Nzoia	EWR, CW	1		
Ahmed Awadh	Kitale Industries	Grain Processor	10-Feb	Kitale	Trans Nzoia	EWR, CW	1		
Jennifer Olesia	Kitale market	Grain Trader	10-Feb	Kitale	Trans Nzoia	EWR, CW		1	
Nora Membo	Kitale market	Grain Trader	10-Feb	Kitale	Trans Nzoia	EWR, CW		1	
Charles Onyango	KEPHIS	Certification	13-Feb	Kitale	Trans Nzoia	CW	1		
Kenneth Kagai	Minstry of Agric.	Extension	14-Feb	Kitale	Trans Nzoia	CW	1		
Hellen Wambui		Grain Trader	15-Feb	Kitale	Trans Nzoia	CW		1	
Iddi Meli		Seed Seller	15-Feb	Kitale	Trans Nzoia	CW	1		
Stephen Akoto	vi-Agroforestry	Extension	15-Feb	Kitale	Trans Nzoia	CW	1		
Felistus Barasa		Farmer	14-Feb	Kiungani Village	Trans Nzoia	CW		1	
Peris Ekimat		Farmer	14-Feb	Kiungani Village	Trans Nzoia	CW		1	
Emily Lutacho		Farmer	13-Feb	Machungwa	Trans Nzoia	CW		1	
Josephine Mayodi		Farmer	13-Feb	Machungwa	Trans Nzoia	CW		1	
Ruth Ocham		Farmer	13-Feb	Machungwa	Trans Nzoia	CW		1	
Reuben Biwot	Farmers Group	Seed Producer	14-Feb	Toro Farm	Trans Nzoia	CW	7		
George Otiep	AEP Caritas-Hamabay	Other	8-Feb	Kisumu	Homabay	EWR, CW	1		
Pamela Ojhor	AEP Caritas-Hamabay	Other	8-Feb	Kisumu	Homabay	EWR, CW		1	1

Name	Organization	Actor Category	Date	Location	County	Int*	M	F	P
Beatrice Otieno	AEP Caritas-Homabay	Other	8-Feb	Kisumu	Homabay	EWR, CW		1	
Joseph A Lynette M	KEPHIS	Certification	9-Feb	Kisumu	Kisumu	EWR, CW	1	1	
Zilpah Odondi		Farmer	16-Feb	Nyakongo Location	Homabay	CW		1	
Octave Ayieko	West Karachuonyo Seed Growers	Seed Producer	17-Feb	Ndare Primary	Homabay	CW	1		1
John Odoyo	Angwete Seed Bulk-ers	Seed Producer	17-Feb	Ndare Primary	Homabay	CW	1		
Boaz Nyateng	Lambwe Seeds Growers Assoc.	Seed Co.	17-Feb	Lambwe	Homabay	CW	3		1
Charles Otieno		Grain Trader	17-Feb	HomaBay	Homabay	TO	1		
Margaret Odongo		Grain Trader	17-Feb	HomaBay	Homabay	TO		1	
Pamela Owala		Grain Trader	17-Feb	HomaBay	Homabay	TO		1	
Peter Ochieng		Seed Seller	17-Feb	Rodi	Homabay	TO	1		
Abigael Og-alo		Seed Seller	17-Feb	Rodi	Homabay	TO		1	
Everline Ambogo		Seed Seller	17-Feb	Rodi	Homabay	TO		1	
Erick Otieno		Farmer	19-Feb	Wiobiero	Homabay	TO	1		
Joanes Ouma Muga		Farmer	19-Feb	Marindi	Homabay	TO	1		
Nancy Ouru		Farmer	19-Feb	Sero	Homabay	TO		1	
Dorothy Otieno		Farmer	19-Feb	Marindi	Homabay	TO		1	
Michael Otieno		Farmer	19-Feb	Wiobiero	Homabay	TO	1		
Bernard Mboya		Farmer	20-Feb	Kirindo	Homabay	TO	1		
David Mboya		Farmer	20-Feb	Kirindo	Homabay	TO	1		
Lucy Akinyi		Farmer	20-Feb	Kirindo	Homabay	TO		1	
Hallorine Otieno	Ministry of Agriculture	Extension	20-Feb	HomaBay	Homabay	CW		1	1
Samuel Sana		Farmer	7-Feb	Lambwe	Homabay	CW	1		
Maurine Omolo		Farmer	8-Feb	Samanga	Homabay	CW		1	
Perpetua Wasonga	Farmers group	Farmer - Other	8-Feb	Samanga	Homabay	CW		3	
Helena Otae		Farmer	9-Feb	Sero	Homabay	CW		1	
Radgunda Diang'a		Farmer	9-Feb	Sero	Homabay	CW		1	

Name	Organization	Actor Category	Date	Location	County	Int*	M	F	P
Anjelina Olunga		Farmer	9-Feb	Sero	Homabay	CW		1	
Phillip Kajwang'	Transu Limited	Grain Trader	13-Feb	Kisumu	Homabay	CW	1		
Anna Ogowo		Grain Processor	13-Feb	Ng'ou Beach	Homabay	CW		1	
Duncan Onduu	Seed Trade Assoc of Kenya (STAK)	Other	7-Feb	Nairobi	Nairobi	EWR, FR	1		1
Desterio Nyamogo	KALRO	Genetic Resources	7-Feb	Nairobi	Nairobi	EWR, FR	1		
James Mutonyi	AGMARK	Other	7-Feb	Nairobi	Nairobi	EWR, FR	2		
Hugo de Groote	CIMMYT	Other	7-Feb	Nairobi	Nairobi	EWR			
Emilia Tjernstrom	University of Wisconsin	Other	8-Feb	Nairobi	Nairobi	FR		1	
Julia Franklin	One Acre Fund	Other	8-Feb	Nairobi	Nairobi	FR		1	
David Priest	Farm Input Promotions Africa (FIPS-Africa)	Other	16-Feb	Nairobi	Nairobi	EWR			
Evans Ouma	Rongo University	Breeder	17-Feb	Nairobi	Nairobi	EWR			
Emily Too, Beatrice Were	Eldoret University	Breeder	17-Feb	Nairobi	Nairobi	EWR			
Joe de Vries	AGRA	Other	20-Feb	Nairobi	Nairobi	EWR, FR			
Moisisa Regasa	CIMMYT	Other	21-Feb	Nairobi	Nairobi	EWR, FR			
Hugo Wood	Olerai Seed Company	Seed Co.	24-Feb	Nairobi	Nairobi	EWR			
Saleem Email	Western Seed	Seed Co. - Breeder	8-Feb	Nairobi	Nairobi	FR	1		1
Philip Lelily	KALRO	Breeder	9-Feb	Nairobi	Nairobi	FR, WM	1		
Rose Mutuku	Smart Logistics Solutions Ltd.	Grain Trader	9-Feb	Machakos	Machakos	FR, WM		1	
Ngila Kimotho	Dryland Seed	Seed Co.	9-Feb	Machakos	Machakos	FR, WM	1		1
Pamela Nkatha	FIPS-Africa	Other	10-Feb	Tawa	Machakos	FR, WM		1	
Esther	Eastern Agrovet	Seed Seller	10-Feb	Masii	Machakos	FR, WM		1	
Petronila	Farmers Senta (Agrovet)	Seed Seller	10-Feb	Tawa	Machakos	FR, WM		1	
Jacinta Mwendu	Dryland Seed Sales Rep.	Seed Co.	10-Feb	Machakos	Machakos	FR, WM		1	
Fareday Muthoka		Seed Producer	10-Feb	Katumani	Machakos	FR, WM	1		
Name	Organization	Actor Category	Date	Location	County	Int*	M	F	P

Clement Kamau	KALRO	Breeder	10-Feb	Katumani	Machakos	FR, WM	1		
Daniel Mulwa	KALRO Seed Unit	Other	10-Feb	Katumani	Machakos	FR, WM	1		1

* Interviewers denoted:

CW Dr Charles Wasonga
EM Eric Murithi
EWR Dr Eva Weltzien-Rattunde
FR Dr Fred Rattunde
SK Dr Simon Kimenju
TO Tobias Ochola
WM Dr Wellington Mulinge

B. COMPLETE LIST OF INTERVIEWS CONDUCTED IN MALI, 1-21 MARCH 2017

Listed are names of those interviewed, their organization and actor category, location, interviewer (see explanation below), numbers of male (M) and female (F) interviewees, and workshop participants (P).

Name	Organization	Actor Category	Date	Location	Region	Int*	M	F	P
Aisatta Konaté, Oumar Togo	Coop Amasagou Assoc. Menekuno	Seed Co.	4-Mar	Koporona	Mopti	FR HG	1	6	
Moussa G, Allaye G, Dougoutigi		Other	4-Mar	Teli	Mopti	FR HG	3		
Assetou Traoré Diallo		Grain Processor	5-Mar	Sevaré	Mopti	FR HG		1	
Sory Mamoutou Tangara		Farmer	5-Mar	Somadougou	Mopti	FR	1		
Aminata Dembelé		Farmer	5-Mar	Somadougou	Mopti	HG		1	
Alhassane Serra	Coop Soromonyo	Seed Co.	5-Mar	Somadougou	Mopti	FR HG	1		
Moussa Kamia Dougoutigi		Farmer	5-Mar	Soufouroulay	Mopti	FR HG		1	
Nanta Kamia		Farmer	5-Mar	Soufouroulay	Mopti	FR HG		1	
Issa Sunguro, Babbi Kamia		Farmer	5-Mar	Soufouroulay	Mopti	FR HG	2		
Issa Traoré, Abdoulaye C	Assoc. Sabunyama	Seed Co. Farmer	5-Mar	Perempé	Mopti	FR HG	2		1
Aminata Fofana	CRS-Mopti	Other	6-Mar	Sevaré	Mopti	FR HG		1	
Mama Diarra		Farmer	6-Mar	Orgnon	Mopti	HG	1		
Goumou Cissé		Farmer	6-Mar	Perempé	Mopti	HG		1	
Lamine Troaré		Grain Trader	7-Mar	Sevaré	Mopti	HG	1		
Mariam Maiga		Grain Trader	7-Mar	Sevaré	Mopti	HG		1	
Lamine Konta		Grain Trader	7-Mar	Sevaré	Mopti	HG	1		
Temory Malick		Farmer	8-Mar	Guro Néma	Mopti	HG	1		
Fatoumata Diarra		Farmer	8-Mar	Guro Néma	Mopti	HG		1	
Moussa Sidibé		Farmer	8-Mar	Guro Néma	Mopti	HG	1		
Daouda D Issa D Ali Z	Coop Soromonyo	Seed Co.	2-Mar	Somadougou	Mopti	FR HG	3		
Hamadoun Korobara		Farmer	8-Mar	Daladougou	Mopti	HG	1		
N'Ti Diarra		Seed Producer Farmer	9-Mar	Orgnon	Mopti	HG	1		

Name	Organization	Actor Category	Date	Location	Region	Int*	M	F	P
Koni Séremé		Farmer	9-Mar	Orgnon	Mopti	HG		1	
Issa Diarra		Farmer	9-Mar	Orgnon	Mopti	HG	1		
Djeneba Traoré		Farmer	11-Mar	Bima	Mopti	HG		1	
Djeneba Boré		Farmer	11-Mar	Boré	Mopti	HG		1	
Fanta Dembelé		Farmer	11-Mar	Bima	Mopti	HG		1	
Bakary Traoré		Farmer	11-Mar	Bima	Mopti	HG	1		
Samba Traoré		Farmer	11-Mar	Bima	Mopti	HG	1		
Baba Diarra		Farmer	12-Mar	Hameau-Douentza	Mopti	HG	1		
Ibrahima Dicko	Direction Regionale d'Agriculture	Certification	3-Mar	Sevaré	Mopti	FR HG	3		1
Mafa Haïdara		Farmer	12-Mar	Hameau-Douentza	Mopti	HG	1		
Biba Ongoïba		Grain Trader	12-Mar	Fomboni	Mopti	HG		1	
Allarye Hamidou	Kayi Tourou Djenroun	Seed Co.	13-Mar	Tabi	Mopti	HG	1		
Boureïma Guindo		Farmer	13-Mar	Tabi	Mopti	HG	1		
Hawa Guindo		Farmer	13-Mar	Boni (coline)	Mopti	HG		1	
Husseyni Kokena	CRS-Mopti	Other	3-Mar	Sevaré	Mopti	FR HG	1		
Hamadi Boré	Assoc. Semencier Bidal Sevaré-N	Seed Co.	3-Mar	Sevaré	Mopti	FR HG	1		
Alassane Maïga, Baffa Dembelé	Assoc Prod Sem. Bargundaga, Service Semencier	Seed Co. Other	3-Mar	Mopti	Mopti	FR HG	2		
Amadou Togo, Harouna Togo	Union Amakene Coop Merebara	Other	4-Mar	Tendeley	Mopti	FR HG	8		1
Minedjou Dolo	CRRA Niono	Breeder	2-Mar	Niono	Niono	EWR SG	1		1
Mamdou Dembelé	APS - Km30	Seed Co.	3-Mar	N30 Sidiwala	Niono	EWR SG	1		1
Gaoussou Diarra		Farmer	3-Mar	N5	Niono	EWR SG	1		1
Mah Diarra		Grain Processor Farmer	3-Mar	Niono	Niono	EWR SG		1	
Soumaila Kindo	GIE-ERFEN	Seed Co.	3-Mar	Niono	Niono	EWR SG	1	1	

Name	Organization	Actor Category	Date	Location	Region	Int*	M	F	P
Koke Diarra		Farmer	5-Mar	Nango Sahel	Niono	EWR SG	1		1
Diakaridia Coulibaly		Farmer	5-Mar	Nango Sahel	Niono	EWR SG	1		
Moussa Sacko		Farmer	5-Mar	Nango Sahel	Niono	EWR SG	1		
Checkné Kantako		Grain Trader	5-Mar	Niono Marché	Niono	EWR SG	1		
Mamadou Drago		Grain Trader	5-Mar	Niono Marché	Niono	EWR SG	1		
Zoumana Coulibaly		Grain Trader	5-Mar	Niono Marché	Niono	EWR SG	1		
Mamadou Siby		Seed Producer	7-Mar	Kogoni	Niono	SG	1		
Daouda Mounkoro	Office du Niger	Extension	8-Mar	Diabaly	Niono	SG	1		
Seydou Diallo		Farmer	8-Mar	Massadougou	Niono	SG	1		
Salif Daou		Farmer	8-Mar	Massadougou	Niono	SG	1		
Mariam Samaké		Farmer	9-Mar	Ségou-Coura	Niono	SG		1	
Santan Traoré		Farmer	9-Mar	Ségou-Coura	Niono	SG		1	
Sidiki Sissouma		Farmer	9-Mar	Nies-soumana	Niono	SG	1		
Kilalo Sissouma		Farmer	9-Mar	Nies-soumana	Niono	SG		1	
Abdoul Nasser Hamaïdou	Cooperative Jama Djigi de Molodo	Other	11-Mar	Molodo	Niono	SG	1	1	
Barayi Coulibaly		Farmer	11-Mar	Siriwala	Niono	SG	1		
Madou Magara		Farmer	11-Mar	Siriwala	Niono	SG	1		
Gaoussou Coulibaly		Extension	11-Mar	Siriwala/Franfasi-So	Niono	SG	1		
N'Golo Coulibaly	Secteur d'Agr Niono	Certification	11-Mar	Niono	Niono	SG	1		
Ali Tamboura	CPS-R1 M3 Molodo (AOPP)	Seed Co.	11-Mar	M3-Molodo	Niono	SG	1		
Diakaridia Coulibaly		Seed Producer	15-Mar	Kourouma-Coura	Niono	SG	1		
Ousmane Djire	CAFON	Other	6-Mar	Niono	Niono	EWR	1		
Cheick Keita	Faranfasiso	Grain Trader	6-Mar	Niono	Niono	EWR	1		
Assan Keita	Office du Niger	Extension	3-Mar	Niono	Niono	EWR SG		1	
Mr. Kebe	Office du Niger	Extension	3-Mar	Niono	Niono	EWR SG	1		

Name	Organization	Actor Category	Date	Location	Region	Int*	M	F	P
Moussa Sanogo	IER	Breeder	1-Mar	Ségou	Ségou	FR	1		
Amadou Sidibé	Agregator	Grain Trader	2-Mar	Cinzana Gar	Ségou	FR HG	1		
Yoro Bah Ali Bah		Farmer	6-Mar	Bembugu Were	Ségou	EWR	4		
Adama Dembele	Sous secteur agricole, DRA	Extension	6-Mar	Markala	Ségou	EWR Toure	1		1
Mamoutou Kane	FasoJigi/PAC-CEM Union of Coop	Grain Trader Seed Producer	6-Mar	Ségou	Ségou	EWR	1		1
Ousmane Thera	Agrisahel	Seed Seller	6-Mar	Ségou	Ségou	EWR	1		1
Sidi Bekaye Coulibaly	IER	Other	7-Mar	Cinzana-SRA	Ségou	EWR	2		
Issiaka Ballo Siali Toure	CPDSC: Cooperative des prod. et distr. semence de Cinzana	Seed Co.	7-Mar	Cinzana-Gare	Ségou	EWR	2		
Issiaka Ballo, Siali Toure		Farmer	7-Mar	Cinzana-Gare	Ségou	EWR	2		
Sauti Toure		Farmer	7-Mar	Cinzana-Gare	Ségou	EWR	1		
Assitan Couliaby		Farmer	7-Mar	Sandogola, commune de Cinzana	Ségou	EWR		1	
Christine Koné, Jeanne d'Arc Coulibaly	3 Womens Groups- Seed Coop	Grain Processor	7-Mar	Minankofa, commune de Cinzana	Ségou	EWR		4	
Mathieu Coulibaly	Cooperative Semenciere Minankofa	Seed Producer	7-Mar	Minankofa, commune de Cinzana	Ségou	EWR	7		
Marc Moukoro	Cooperative semencier de Minakofa	Seed Co.	7-Mar	Minankofa	Ségou	EWR	1		
Sirasse Cisse, Siraman Samaké	Service Semencier National	Certification	8-Mar	Ségou	Ségou	EWR	2		
Henri Coulibaly, Tiedo Kann	Association des Organisations Paysannes Professionnelles AOPP-Ségou	Other	8-Mar	Ségou	Ségou	EWR	2		
Oumar Traoré		Farmer	4-Mar	Tio	Ségou	EWR SG	1		
Groupe d'hommes		Farmer	4-Mar	Tio	Ségou	EWR SG	1		
Sayon Traoré		Farmer	4-Mar	Tio	Ségou	EWR SG	1		
Name	Organization	Actor Category	Date	Location	Region	Int*	M	F	P

Madou Diarra		Farmer	4-Mar	Tio	Ségou	EWR SG	1		
Moussa Traoré		Farmer	4-Mar	Tio	Ségou	EWR SG			
Groupe d'hommes		Farmer	4-Mar	Kungobugu Sokala	Ségou	EWR SG	1		
Adama Coulibaly		Farmer	4-Mar	Kungobugu Sokala	Ségou	EWR SG	1		1
Hamidou Coulibaly		Farmer	4-Mar	Kungobugu Sokala	Ségou	EWR SG	1		
Seriba Tangara		Farmer	12-Mar	Bambougou	Ségou	SG	1		
Adama Sangaré		Farmer	12-Mar	Bambougou	Ségou	SG	1		
Youssef Dembélé		Farmer	12-Mar	Bambougou	Ségou	SG	1		
Nana Dembélé		Seed Seller	12-Mar	Markala	Ségou	SG		1	1
Mamadou Goita, Pres	Seneyiriwaton	Other	6-Mar	Koutiala	Koutiala	FR JT	1		1
Mamadou Keita	PDRN	Seed Co.	7-Mar	Koutiala	Koutiala	FR JT	1		
Mme Ouattara, Mariama Sano, Souleyman Coulibaly employee	Nieta	Farmer	7-Mar	Koutiala	Koutiala	FR JT	1	1	
El Hadj Moussa Traoré, Pres.	Union des Cooperatives Semencieres Cercle de Koutiala	Other	7-Mar	Koutiala	Koutiala	FR JT	1		
Yousuf Goita, Jean Goita, Mamdou Coulibaly	Sibougouton Coop. Semencier Yorosso	Seed Producer Farmer	7-Mar	Koutiala	Koutiala	FR JT	3		
Moumouni D Madou T	Coop. Semencier Jigifa	Seed Co.	7-Mar	Koutiala	Koutiala	FR JT	2		
Yah Diakité	AMASSA	Other	7-Mar	Koutiala	Koutiala	FR JT		1	
Oumar Samaké	AMEDD	Other	7-Mar	Koutiala	Koutiala	FR JT	1		1
Solo D, Moussa D		Farmer	8-Mar	Sirakele	Koutiala	FR JT	3		
Mariam Sara		Farmer	8-Mar	Sirakele	Koutiala	FR JT		6	1
Simeon Coulibaly	AV Cotton	Farmer	8-Mar	Kinteri	Koutiala	FR JT	2		
Nuhun Diallo	Dunkafa	Farmer	8-Mar	Kinteri	Koutiala	FR JT	1		1
Kadiatou Coulibaly		Farmer	8-Mar	Mpessoba	Koutiala	FR JT		1	
Soulimane Balo	Jigiseme Mpessoba	Seed Co. Farmer	8-Mar	Mpessoba	Koutiala	FR JT	2		1
Name	Organization	Actor Category	Date	Location	Region	Int*	M	F	P

Bourema Di- arra	CMDT	Other	9-Mar	Koutiala	Koutiala	FR JT	1		
Lamine Koné	Coop. Wonkon	Grain Processor	9-Mar	Karangana	Koutiala	FR JT	1		1
Oumar Jimde		Farmer	9-Mar	Koro	Koutiala	FR JT	1		
Issa Traoré	Coop. Jigiya	Seed Co.	9-Mar	Ngountjina	Koutiala	FR JT	1		
Issa Mpe Dembelé	Coop. Semencier Ngountjina	Seed Co.	9-Mar	Ngountjina	Koutiala	FR JT	1		
Hommes Ko- loto		Farmer	10- Mar	Koloto	Koutiala	FR JT	12		
Fatomata Nantomé		Farmer	10- Mar	Koloto	Koutiala	FR JT		1	
Ladji Goro	Arc en Ciel	Seed Seller	13- Mar	Koutiala	Koutiala	JT	1		
Abdoule Wahabe Maiga	Ozobolla Service	Seed Seller	15- Mar	Koutiala	Koutiala	JT	1		
Gaoussou Traoré	Comptoire 2000	Seed Seller	15- Mar	Koutiala	Koutiala	JT	1		
Drissa Berthé		Farmer	10- Mar	Jirikorola	Sikasso	FR JT	2		
Chiaka Traoré		Grain Trader Farmer	10- Mar	Lutana	Sikasso	FR JT	1		
Bintou Berthé	Fokabe Lutana	Seed Co.	10- Mar	Lutana	Sikasso	FR JT		2	1
Djibril T, Chiaka T	Nipagnon Lu- tana	Seed Co.	10- Mar	Sikasso	Sikasso	FR JT	1		
Kokozié Traoré	Soprosa	Seed Co.	10- Mar	Sikasso	Sikasso	FR JT	1		
Binof Cou- libaly (coop. Sec), Family Diallo		Farmer	11- Mar	Noupagag- non, Nagola	Sikasso	FR JT	2		
Fanta Di- amoutene (Madam Sanogo)	Union des Pro- ducteurs et Transformateurs des Cereales	Grain Processor	11- Mar	Farakala	Sikasso	FR JT		1	1
Naza Sanogo (pres.)	Cooperative des Femmes Agri- cole de Farakala (COFAF)	Seed Co.	11- Mar	Farakala	Sikasso	FR JT		1	
Yaya Sogodogo		Farmer	11- Mar	Farakala	Sikasso	FR JT	1		
Guedjouma Sanogo	Senekelaw Jigisigiyoro	Seed Seller	12- Mar	Sikasso	Sikasso	JT	1		
Dramane Berthé	Sènèguiya-So	Seed Seller	12- Mar	Sikasso	Sikasso	JT	1		

Name	Organization	Actor Category	Date	Location	Region	Int*	M	F	P
------	--------------	-------------------	------	----------	--------	------	---	---	---

Rokia Goldmann, Jigiba Kouaté, Juergen Hoerner	GIZ	Other	21- Mar	Bamako	Bamako	EWR FR	2	1	
Abdoulye Diallo	IER	Breeder	6-Mar	Bamako	Bamako	FR	1		1
Aboubacar Touré, Baloua N	ICRISAT	Breeder	15- Mar	Bamako	Bamako	FR	2		
Mamourou Sidibé	ICRISAT	Other	20- Mar	Bamako	Bamako	EWR FR	1		
Samba Troaré	IER	Other	20- Mar	Bamako	Bamako	EWR FR	1		
Fousseini Yamba	IER-Centre d'In- cubation	Grain Processor	20- Mar	Bamako	Bamako	EWR FR	1		
Niaba Temé	IER-Laboratoire Biotechnologie	Breeder	20- Mar	Bamako	Bamako	EWR FR	1		
Minamba Bagayoko	IER Direction Scientifique CNS Riz	Other	21- Mar	Bamako	Bamako	EWR FR	1		
Krista Isaacs	ICRISAT	Other	15- Mar	Bamako	Bamako	FR		1	1
GUINDO Hama		Grain Processor	10- Mar	IER CRRA- Sotuba	Bamako	GC	1		
BALLO Issa		Grain Processor	11- Mar	Korofina- Nord	Bamako	GC	1		
BAGAYOKO Salif		Grain Trader	8-Mar	Niarela	Bamako	GC	1		
KONÉ Mama		Grain Trader	7-Mar	Bagadji	Bamako	GC	1		
SANGARÉ Siné		Grain Trader	4-Mar	Niarela	Bamako	GC	1		
DEMBÉLÉ Mamadou		Grain Trader	8-Mar	Bagadji	Bamako	GC	1		
COULIBALY Yaya		Grain Trader	7-Mar	Bagadadji	Bamako	GC	1		
DIALLO Ma- riam Kalifa		Grain Processor	12- Mar	Bolibana	Bamako	GC		1	1
Mme DADO Nanténé	Dado Production	Grain Processor	9-Mar	Yirimadjo	Bamako	GC		1	
MARIKO Fadima UCO- DAL		Grain Processor	9-Mar	Zone Indus- trielle	Bamako	GC		1	
SANOOGO Di- arra Bintou	Jeka Baara	Grain Processor	9-Mar	Boukassou mbougou	Bamako	GC		1	
DABO Mamady	Dabo Production	Grain Processor	12- Mar	Moribougou	Bamako	GC	1		
Djiguiba Kou- yate	GIZ, Centre Vert d'Innovations	Extension	9-Mar	Bamako	Bamako	EWR	1		
Bokari Timbo	WASP, CNRA	Other	9-Mar	Bamako	Bamako	EWR	1		
Name	Organization	Actor Category	Date	Location	Region	Int*	M	F	P

Djoukamadi Diallo	Labosem	Certification	9-Mar	Bamako	Bamako	EWR	1		
Mamadou Coulibaly	Program Mais	Breeder	9-Mar	Bamako	Bamako	EWR	1		1
Mamadou Makadji	Doukafa	Seed Co.	9-Mar	Bamako	Bamako	EWR	1		
Amadou Sidibe	IER Unite Ressource Genetique	Genetic Resources	10-Mar	Bamako	Bamako	EWR	1		
Maimouna Coulibaly	FasoKaba	Seed Co.	10-Mar	Bamako	Bamako	EWR		1	
Mamadou Kayentao	Agriplus	Seed Co.	10-Mar	Bamako	Bamako	EWR	1		
Oumar Coumare	AOPP - Seed advisor	Other	10-Mar	Bamako	Bamako	EWR	1		

*Interviewers

HG Hamidou Guindo

EWR Dr Eva Weltzien-Rattunde

SG Samuel Guindo

FR Dr Fred Rattunde

JT Joel Tangara

GC Gabriel Coulibaly

C. LIST OF WORKSHOP PARTICIPANTS IN KENYA

Listed are names of participants, gender, organization (if any), actor type, locality and region.

No.	Name	Gender	Organization	Actor Type	Locality	County
1	Simon Mitambo	m	African Biodiversity Network (ABN)	NGO		
2	Caroline M. Kavu	f	KEPHIS	Variety registration/seed regulation		
3	Octave Ayieko			Seed bulker	West Karachuonyo	Homabay
4	Simon Kimenju	m	Consultant	Study team	Nairobi	
5	Eric Murithi	m	Consultant	Study team	Nairobi	
6	Charles Wasonga	m	Consultant	Study team	Migori	
7	Duncan Ochieng Onduu	m	Seed Trade Association of Kenya (STAK)	Association of seed companies		
8	Daniel M. Mulwa	m	KALRO	Seed production manager	Machakos	
9	Omari M. Odongo		KALRO	Plant breeder	Kitale	
10	Ngila Kimotho		Dryland Seeds	Director, seed company		
11	Saleem Esmail	m	Western Seed Company Ltd	CEO, plant breeder		
12	Boaz Ouma Nyateng		Lambwe Seed Growers association (LASGA)	Coordinator, Seed producer association		
13	Lawrence Mose	m	KALRO	Study team		
14	Michael Kitur	m		Farmer, coordinator of farmer group		Trans Nzoia
15	Robina Karimi Kaibiru	f		Farmer, trainer	Tharaka	Tharaka Nithi
16	Wellington Mulinge	m	KALRO	Researcher		
17	Allan Mutegi	m		Farmer, agro-dealer	Tharaka	Tharaka Nithi
18	Jeremy Mwiti	m		Farmer, aggregator	Tharaka	Tharaka Nithi
19	Pamela Ojhoru	f	CARITAS	Extension agent		Homabay
20	Hallorine Aketch Otieno		Ministry of Agriculture	Extension agent		Homabay
21	Paul Lelei Too	m		Chairman, association of agro-dealers		Trans Nzoia
22	Martin Mwasya	m		Farmer	Tharaka	Tharaka Nithi
23	Eva Weltzien Rattunde	f		Study team		
24	Fred Rattunde	m		Study team		

D. LIST OF WORKSHOP PARTICIPANTS IN MALI

Listed are names of participants, gender, organization (if any), actor type, locality and region/district.

No.	Name	Gender	Organization	Actor Type	Locality	Region/district
1	Mamadou Dembelé	m	APS Siritwala	Prod Semence Coop/Assoc/Union	Niono	Ségou
2	Gaoussou Diarra	m	AV N5	Paysan selectionneur riz	Niono	Ségou
3	Menidiou Dolo	m	IER-Niono	Selectionneur	Niono	Ségou
4	Koke Diarra	m	APCAM Niono	Producteur riz	Niono	Ségou
5	Henri Coulibaly	m	AOPP-Ségou	Coordinateur comite de semence Ségou	Ségou	Ségou
6	Adama Dembele	m	DRA Ségou (Markala)	vulgarisation	Markala	Ségou
7	Adama Coulibaly	m	Kongobugu village	Producteur	Markala	Ségou
8	Mme Traoré Nana Dembelé	f		Agrodealer	Markala	Ségou
9	Mamoutou Kané	m	Faso Jigi/PACCEM	Secrétaire Exécutif	Ségou	Ségou
10	Ibrahima Dicko	m	DRA-Mopti	Controlleur, Certification, législation	Sevaré	Mopti
11	Oumar Togo	m	Coop Merinbara, Union Amakene de Tendeley	Union Commercialisation grain, prod Semence Mil	Tendeley	Mopti
12	Issa Traoré	m	Benkadi	Producteur Mil/Riz Prod Semence, Coop	Perempe	Mopti
13	Mamadou Kayentao	f	Agriplus - Mali	Secteur Privée	Bamako	Bamako
14	Mamadou Coulibaly	m	IER	Selectionneur Mais	Bamako	Bamako
15	Mme Diallo Mariam Khalifa Trore	m	Coop Benso	Transformatrice	Bamako	Bamako
16	Krista Isaacs	f	ICRISAT	Chercheur	Bamako	Bamako
17	Mamadou Goita	m	Seneyirawatou, AP-CAM-Sikasso	Union/Fédération Coop Semenciers	Kiffosso	Koutiala
18	Mariam Sara	f	uda-uyena	Coop Feminine Agricole, production de semence	Sirakele	Koutiala
19	Nouhoum Diallo	m	Dunkafa	Prod Semence Coop	Kintieri	Koutiala

Annex

20	Solomane Ballo	m	Jigiseme Mpepoba	Prod Semence Union	Mpepoba	Koutiala
21	Oumar Samaké	m	AMEDD	, reglementation semence	Koutiala	Koutiala
22	Lamine Koné	m	Coop. Wonkon	Transform, Commerc. Grain, Prod. Semence Coop	Karangana	Koutiala
23	Diarrah Traore	f	Fokaben, women's coop	Commercialisation Riz Graine+Semence	Lutana	Sikasso
24	Fanta Diamoutene	f	COFAF Coop des Femmes Agricole de Farakala	Productrice	Farakala	Sikasso
25	Joel Tangara	m	AMASSSA	Technicien	Koutiala	Sikasso
26	Hamidou Guindo	m	3A Sahel	Agronome	Douentza	Mopti
27	Samuel Guindo	m	FSAD	Agronome	Diabaly	Ségou
28	Gabriel Coulibaly	m	Foranim	Facilitateur	Bamako	Bamako
29	Fred Rattunde	m	Consultant	Selectionneur	Remagen	Allemagne
30	Eva Weltzien	f	Consultant	Selectionneur	Remagen	Allemagne
31	Alpha Kergna	m	IER-Ecofil	Economiste	Bamako	Bamako
32	Brahima Cissouma	m	Faso Jigi	Producteur	Niono	Ségou

E. SPECIFIC SUGGESTIONS FOR SEED SYSTEM ENHANCEMENT BY CROP AND COUNTRY

Suggestions for specific actions to build capacity and strengthen seed system innovation for each crop studied in Mali and Kenya are presented on the following pages. The numerous suggestions listed here consist of the distilled experiences and visions for improvements shared by the full range of actors during field interviews, the priorities indicated by participants at the national workshops, and our own syntheses and observations.

We are aware that the legal space for implementing some of the suggested actions would need to be carefully assessed together with relevant actors, e.g. government bodies responsible for variety registration and seed certification, and in close collaboration with them, prior to taking steps for implementation. However, possibilities for registration of extant varieties, or varieties with specific adaptation and uses, have been created in several countries, including the EU, to allow for legal seed production and distribution to interested users, even if these varieties do not fully comply with 'normal' registration requirements (e.g. DUS criteria, VCU test).

The suggested actions are organized according to the major entry points for strengthening the collaborative process of seed system functioning, as reported in Chapter 7 of the study. These actions, therefore, represent a proposed agenda for strengthening innovation in these staple cereal seed system in a sustainable manner. This compilation of suggested actions can help all seed system actors to reflect on possible contributions that each can make to overcome constraints and realize opportunities for enhancing the dynamics of the staple-cereal seed systems in which they are involved.

KENYA: SORGHUM SEED SYSTEMS FOR DIVERSE AGROECOLOGIES AND PRODUCTION SYSTEMS

Entry Point	Specific Suggestions for capacity building and seed system innovation
Actor Orientation: A Vital and Complementary Perspective for Seed System Development	<ul style="list-style-type: none"> • Facilitated stakeholder discussions at county and national levels addressing the following issues: <ul style="list-style-type: none"> ○ Exploring options for systems such as “Quality Declared Seed” (QDS), with a view towards <ul style="list-style-type: none"> ▪ Adapting the variety-release procedures, such that seed of specific local varieties can be commercialized and become more widely available. ▪ Reducing delays for seed certification. ▪ County-level consultations for improving seed availability across the county, as well information about information sharing.
“Farmer First” – A Necessary Perspective	<ul style="list-style-type: none"> • Giving sorghum farmers more varietal choice, particularly for maturity, grain quality and adaptation traits, and responding to farmers’ desire for improved availability of local varieties. • More explicit effort to disseminate sorghum varieties that serve farmers’ specific and contrasting production systems and objectives, e.g. production of grain for market and/or consumption, biomass for erosion control or other purposes, ratooning ability. • More explicit efforts for setting sorghum breeding objectives to respond to the diversity of farmers’ needs with respect to sorghum varietal preferences, within a vision for the development of their production system options. • Explore options for facilitating networking among farmer groups or organizations in the context of sorghum seed system development. • Building farmers’ and groups capacities for seed production and dissemination, including storage facilities. • Develop credit facilities to support farmer-managed seed production and dissemination enterprises. • Improve the quality of information and methods of communication to responds to the diversity of farmers’ needs.
Improved Collection and Sharing of Varietal Information and Performance Data	<ul style="list-style-type: none"> • Contribute to capacity of Kenyan farmer associations to gather and share information about sorghum variety attributes and performance under specific conditions (e.g. KENFAP, KENAFF). • Allow and facilitate public access to sorghum performance data collected with public funds, such as NPT results. • Revive extension capacities, exploring options using information technologies in a targeted manner. • More systematic sharing of information among publicly funded actors (Universities, KALRO, ICRISAT, NGO’s) active in sorghum variety development and seed related functions, for making generating more interest, demand for seed, as well as future support. • Explore and evaluate ways of increasing awareness of sorghum hybrids and making them available to farmers.
Strengthening Farmer Cooperatives and Their Networks	<ul style="list-style-type: none"> • As few private seed companies are interested in sorghum, and the areas where sorghum is presently grown are geographically distinct, with diverse production systems, there seem to be opportunities for enhancing farmers’ cooperative capacities especially for seed production and dissemination, but also for contributing to variety identification, as has been initiated by some sorghum breeders from universities based in sorghum growing areas. • As sorghum is becoming more of a marketable crop, study and explore collective grain marketing models, identifying factors for success and documenting outcomes such as income generation and building social capital.

	<ul style="list-style-type: none"> • Explore possibilities to facilitate networking among local farmer groups and organizations for sorghum seed system development.
Integrate Plant Breeding as Part of Seed System Development	<ul style="list-style-type: none"> • More targeted variety development to drive seed system growth, serving the contrasting production zones, objectives and environments with more, diverse and adapted varieties, including hybrids. • Building local capacity for collaborating in sorghum variety development to enable more user-responsive varietal creation, realize advantages of cost-efficient breeding for diverse target environments, and providing clearer directions for seed production and dissemination (with clear arrangements for sharing benefits in the diverse sorghum production areas of Kenya). • Link the growing malting industries more closely with sorghum seed and variety development platforms to help guide and mobilize financial support. • Respond to new emerging opportunities or constraints due to climate change or pest outbreak such as the current 'Fall Armyworm' infestation.
Moving Resources From Control and Relief to Creativity and Resilience	<ul style="list-style-type: none"> • Strengthen awareness of the need to increase diversity of commercially available sorghum varieties and mobilize support for new regulatory, dissemination and variety creation innovations that offer farmers more varietal choices. • Study and explore the collaborative model that university sorghum breeders and farmer groups in Western Kenya are pursuing to deliver appropriate varieties for Kenya's distinct sorghum agroecologies. • Invest in diversifying sorghum grain use and processing options, including opportunities for improving human nutrition with sorghum consumption, and thus enhancing market demand for sorghum and sorghum farmers' incomes in the drier, more drought prone areas of Kenya. • Increase awareness of <ul style="list-style-type: none"> ○ various negative outcomes of free seed distributions, and ○ investment options that support more farmer responsive, sustainable and long-term profitability of seed dissemination innovations.

KENYA: MAIZE SEED SYSTEMS FOR DIVERSE AGROECOLOGIES AND PRODUCTION SYSTEMS

Entry Point	Specific Suggestions for capacity building and seed system innovation
<p>Actor Orientation: A Vital and Complementary Perspective for Seed System Development</p>	<ul style="list-style-type: none"> • Seek ways to balance complementarity and competition between private seed companies and of parastatal or state-run seed companies, such as KSC, ADC or the KALRO Seed Unit, to best serve the many, highly diverse maize farmers with distinct production systems, ecologies and varietal preferences (inclusion of all concerned actors, including farmers, seems critical). • Seed certification and related regulations cause delays, thus a wide range of actors are interested to explore options for systems such as QDS, which require stakeholder discussions for possible implementation. • Address issues related to slow turnover of maize hybrids, through enhancing farmer input into priority setting for breeding, resolving issues around licensing of new hybrids, as well as streamlining the process for rendering certified seed of new hybrids available to farmers, through stakeholder consultations. • Joint learning on seed dissemination in diverse situations based on experiences of different actors, projects, initiatives and reviews, including the benefits from free seed distributions. • In the context of the high frequency of poor germination of hybrid maize seed explore options jointly with all concerned actors (e.g. seed companies, distributors and retail sellers, regulatory specialists and farmers) for dealing with unsold maize hybrid seed stocks and the manner of how seed is treated to reduce germination problems in carry-over seed stocks, as well as traceability of seed being sold.
<p>“Farmer First” – A Necessary Perspective</p>	<ul style="list-style-type: none"> • Obtain farmer feedback on experiences with existing varieties and preferences for varietal improvements, such as the requests heard during this study: traits related to food quality for home consumption, as well as for grain storage, but also for improved adaptation to specific conditions, i.e. resistances to MLN, lodging, ear and grain mold resistances. • Smallholder women farmers regularly expressed needs for smaller seed packet sizes, information accessible and useful to them, as well as specific grain qualities and variety adaptations. • Women farmers expressed difficulties with having the means to access hybrid maize seeds more often than men. Targeted efforts for overcoming this bottleneck may be beneficial for household food security. • Seed companies to be more accountable to farmers, including taking full liability for the quality of their seed, with no additional insurance charges (at present farmers have to pay additionally for insurance of seed quality (i.e. good germination and genetic identity). • Improve understanding of women farmers’ needs and preferences for varietal traits, especially with a vision of developing their maize production system options. • Improve the quality of information and methods of communication to better respond to smallholder farmers’ (including women’s) particular production and social contexts, including explicit gender-inclusive communication practices.
<p>Improved Collection and Sharing of Varietal Information and Performance Data</p>	<ul style="list-style-type: none"> • Contribute to capacity of Kenyan farmer associations (e.g. KENFAP, KENAFF) to gather and share information about maize variety and hybrid attributes and their performances under specific conditions. • Allow and facilitate public access to maize hybrid and variety performance data collected with public funds, such as the NPT results. • Seed companies should provide more information, electronically also as well as pamphlets and others, with the content improved to be more useful to farmers. • Explore and facilitate options for farmer on-farm experiential learning, as it is not just verbal information but direct experience of farmers trying out new varieties themselves that is highly important, probably best as a group activity to favor sharing of results and experiences.

	<ul style="list-style-type: none"> • Explore options for impartial regional variety performance data collection, empowering ‘new’ actors like county extension agencies, farmer organizations, NGOs with extensive seed dissemination activities, etc. • More regular exchanges between seed company representatives and farmers seem necessary for companies to improve their services and meet farmers’ demands. • Improve availability of county level (and agroecological zone level) crop production data so that feasibility analyses for targeted breeding and seed system investments can be done.
Strengthening Farmer Cooperatives and Their Networks	<ul style="list-style-type: none"> • Strengthen farmer groups’ capacities to maintain specific landrace varieties. • Farmer seed-producer groups could also develop marketing capacities, possibly in collaboration with owners of the varieties of hybrids, and thus overcome problems with seed availability in areas with sparse agro-dealer networks. • As extension capacity has shrunk in most counties, supporting more direct collaboration, information exchange, and possibly collective marketing among farmers can build capacity for local innovations, also in seed system development. • Explore possibilities for facilitating networks among local farmer groups and organizations for maize seed system development, possibly involving crop researchers.
Integrate Plant Breeding as Part of Seed System Development	<ul style="list-style-type: none"> • Involve KALRO breeders more directly in seed system discussions and consultation meetings. • Improve availability and procedures around making ‘Early Generation Seed’ available to seed producers and companies. • Address issues related to slow turnover of maize hybrids, through improved breeding (in addition to stakeholder discussions, see above). • Increase awareness of variety development for enabling resilient and responsive maize production and seed systems in view of climate change.
Moving Resources From Control and Relief to Creativity and Resilience	<ul style="list-style-type: none"> • Conduct <i>ex ante</i> analysis of alternative seed certification models, evaluating expected benefits and associated problems, including a QDS approach, which puts more direct responsibility on seed providers for the quality of their products. • Assess outcomes of free seed distributions for seed system actors, with a focus on smallholder farmers. • Explore options for more sustained and predictable funding for and accountability of plant breeding programs through shifting funds from free seed distributions to breeding programs. • Conduct <i>ex ante</i> assessment of demand and willingness to pay for smaller seed packets (1kg).

MALI: RICE SEED SYSTEMS FOR DIVERSE AGROECOLOGIES AND PRODUCTION SYSTEMS

Entry Point	Specific Suggestions for capacity building and seed system innovation
<p>Actor Orientation: A Vital and Complementary Perspective for Seed System Development</p>	<ul style="list-style-type: none"> • Ensuring gender representation in priority setting, activity planning and implementation, both in the intensified irrigated and rainfed systems, is vital especially for rice, being traditionally a ‘women’s crop’. • Ensure inclusion of the full range of farmer organizations, cooperatives and farmer specialists collaborating with the IER rice breeding program in planning seed system development activities and investments for specific production systems, and better document this case of ‘demand-led’ farmer-responsive breeding. • Greater attention to implementing seed certification regulations systematically, especially field inspections. • Explore options to help individual farmers to obtain varieties matching their specific needs, e.g. by <ul style="list-style-type: none"> ○ developing a specific registration list for local varieties. ○ maintaining and distributing seed of specific traditional varieties with specific adaptations and grain qualities. ○ pro-active support and explicit engagement with smallholder farmer women’s groups in irrigated rice-systems to facilitate learning and capacity building, especially for those unable to try ‘unknown seed’ on their own without putting themselves and their families at risk.
<p>“Farmer First” – A Necessary Perspective</p>	<ul style="list-style-type: none"> • Continue and support the collaboration of breeders with farmers for conducting breeding programs strongly oriented towards farmers’ priorities in both the irrigated and rainfed rice systems; particularly <ul style="list-style-type: none"> ○ ensure succession as older scientists retire. ○ provide support for breeding methods to enhance genetic gains in both programs. • Respond to demand by certain rice farmers for seed-package sizes smaller than the current 25kg or 50kg bags.
<p>Improved Collection and Sharing of Varietal Information and Performance Data</p>	<ul style="list-style-type: none"> • Integrate specific varietal-performance traits into the tablet-based decision support systems being tested for irrigated rice production. • Improve information about disease threats and susceptibilities for intensified irrigated systems, including <ul style="list-style-type: none"> ○ ‘early warning system’ for disease outbreaks. ○ information about susceptibility and resistance of specific varieties. • Improve information sharing regarding adaptation traits of priority to farmers, e.g. by <ul style="list-style-type: none"> ○ including specific adaptation and resistance traits in varietal descriptions in the National Catalogue, best specified by production systems/environments. ○ improving access to and use of varietal attribute information in the National Catalogue by farmers and other seed system actors. • Make results of comparative variety performance data from the national release system publicly available. • Make results from participatory variety evaluations more accessible to other farmers. • Develop new communication tools in the context of current seed cooperatives and breeder-cooperative networks <ul style="list-style-type: none"> ○ to share information among large farmer-coop membership ○ to enable members and other seed system actors to query the data base for information of local relevance in a timely manner.
<p>Strengthening Farmer Cooperatives and Their Networks</p>	<ul style="list-style-type: none"> • Strengthen and build upon farmer seed-producer groups’ (cooperatives, GIE or informal ‘associations’) capacities for production and sale of certified rice seed in the irrigated rice areas of Niono.

	<ul style="list-style-type: none"> • Enhance interactions among seed cooperatives, as well as with other seed system actors, for general information exchange and better planning of seed production based on needs assessments. • Build linkages and networks among farmer cooperatives for seed provisioning and dissemination, for example exploring options for seed-producer groups in older perimeters to link with and directly distribute seed to newly opened irrigation perimeters. • Explore business opportunities for decentralized mobile seed processing. • Include methods for variety comparison and testing new varieties in Farmer Field Schools (or similar models) for training members of farmer cooperatives (e.g. in collaboration with the 'Green Innovation Center'). • Build upon and strengthen capacities of seed cooperatives for variety testing in collaboration with the IER research station. • Improve capacity for producing pure seed by training seed cooperatives to use the System of Rice Intensification (SRI) for seed production for irrigated systems (single plants are transplanted, seed multiplication ratio is very high).
Integrate Plant Breeding as Part of Seed System Development	<ul style="list-style-type: none"> • Document the collaborative partnerships of IER plant breeders and seed-cooperatives for irrigated and rainfed rice system development as case studies to provide insights and lessons to new scientist and for other crops and countries. • Strengthen collaboration between IER and selected farmer cooperatives to increase the production of high quality breeder and foundation seed for irrigated rice, also in perimeters further away from the research stations. • Maintain or rebuild the research capacity at the IER Niono station for continued rice breeding as well as pathology and entomology research following retirements and an assessment of research facility adequacy. • Explore options to post a plant breeder and research capacity at the IER Mopti station for rice variety development in the natural flooding/submergence production zone of the inner Delta of the Niger River (a production environment for which no variety have been released since 1987).
Moving Resources From Control and Relief to Creativity and Resilience	<ul style="list-style-type: none"> • Do a comparative assessment of Mali's system for varietal release prior to 2015 compared to the process currently being established for regional harmonization for realized/expected facilitation or hindrances to availability, diversity and user-value of new varieties and of any implications for cost of improved seed. This assessment could serve as a case study to guide constructive regulatory approaches across crops not only in Mali but also in other countries with similar contexts. • Examine options for seed dissemination that increase (and justify) farmers' trust, and thereby improve seed availability and minimize farmers' losses due to unadapted seed (such as suffered by rice farmers in the Mopti region with free seed distribution). • Develop more reliable field inspections for seed certification of rice, for which varietal purity is critical, and explore inclusion of control measures practiced by women rice producers (for example as proposed in the Mali workshop). • Encourage the government and donors to focus available resources more on seed-cooperative capacity building and broader collaboration among seed system actors rather than free seed distributions for rice and all other cereals.

MALI: PEARL MILLET SEED SYSTEMS FOR DIVERSE AGROECOLOGIES AND PRODUCTION SYSTEMS

Entry Point	Specific Suggestions for capacity building and seed system innovation
Actor Orientation: A Vital and	<ul style="list-style-type: none"> • Establish and strengthen variety-creation capacity

Complementary Perspective for Seed System Development	<ul style="list-style-type: none"> ○ To serve the several major production systems for which no breeding and no improved varieties are present; pursue options to establish new capacity and new modes of research – e.g. greater reliance on collaboration between breeders across West Africa, and with farmer cooperatives. ○ To strengthen the IER pearl millet breeding program’s capacity to set priorities based on stakeholder consultations and market demand analyses as called for by the national breeder himself. ● Organize stakeholder forums with inclusion of the full range of actors, including farmers, to review seed and variety regulations and their implementation, identify appropriate modifications and facilitate actor buy-in.
“Farmer First” – A Necessary Perspective	<ul style="list-style-type: none"> ● Capitalize on pearl millet farmers’ detailed knowledge and experiences with specific varietal traits for adaptation, yield stability and local use of the grain, especially in the Sahelian zone, to enhance the efficiency and impact of variety improvement research. ● Recognize farmer seed-cooperatives, engaged in producing and selling certified seed, as seed enterprises and enable their inclusion in the Seed Trade Association of Mali, ASSEMA, possibly with a specific membership status. ● Free seed distributions need to focus on specific varietal demands by recipient farmers, which could be assured through a seed fair and voucher system, so that recipient farmers can choose among varieties and local seed enterprises can benefit.
Improved Collection and Sharing of Varietal Information and Performance Data	<ul style="list-style-type: none"> ● Include additional and more specific variety adaptation traits in the variety catalogue, and examine need for providing agroecology-specific variety adaptation information. ● Gather better performance data on new varieties (e.g. with more collaborative testing) and enable better availability of this information to seed enterprises, as well as agrodealers, engaged with pearl millet.
Strengthening Farmer Cooperatives and Their Networks	<ul style="list-style-type: none"> ● Build on the well-functioning pearl millet seed-cooperatives in the Sahelian region of Mali, strengthening them through more targeted collaborative variety development activities. ● Facilitate collaboration among cooperatives in the Sahelian zone, enabling them to function as a resilient network of seed producers and disseminators despite the zone being prone to unpredictable and highly localized weather variability. ● Strengthen the capacities of the seed cooperatives to sell seed treatment with systemic fungicide against ‘Downy Mildew’, contributing to greater returns for the enterprises and higher productivity and yield stability for the farmers ● Explore options for improving the skills and equipment for treating seed on command, both at the cooperative and individual farmers’ level, possible using mobile equipment (attention to the safety of those involved in treating seed and handling treated seed is also needed).
Integrate Plant Breeding as Part of Seed System Development	<ul style="list-style-type: none"> ● Pearl millet as a cross-pollinated crop, with its center of diversity and origin in the western Sahelian region, is undergoing extensive farmer selection in their own seed production with high selection intensities. These farmers’ skills and capacities should be integrated into plant breeding activities, especially for population improvement approaches. ● Focus more attention on the breeding and dissemination of quality seed of appropriate adapted varieties in the northern Guinea-savannah zone, where pearl millet is a secondary crop, as there are good market potentials since pearl millet cultivation is increasing (it fits well into the labor schedules and has high market demand) and farmers may spend less effort for their own seed production.
Moving Resources From	<ul style="list-style-type: none"> ● Establish variety registration options to permit commercial dissemination of specific local varieties, contribute to biodiversity conservation, and improve availability of varieties for specific production systems.

Control and Relief to Creativity and Resilience	<ul style="list-style-type: none">• In the context of seed availability problems in the Sahelian zone due to climate variability, emphasize mobilizing seed resources from known local areas, strengthening business skills of concerned farmers, and possibly local traders, as well as options for improving poor/vulnerable farmers' access to local seed resources via cash transfers or voucher systems (these approaches are justified based on past positive results).• Pearl millet variety development needs to be strengthened significantly so that farmers can improve their yield stability and overall productivity. This crop has big potential, especially in view of rising temperatures during the cropping season.• Government could consider subsidizing certification costs rather than seed distribution.• Seed companies could work in a more pro-active manner with client NGO's to build seed trading networks for more sustained seed availability, especially after the NGO project ends.
---	---

MALI: SORGHUM SEED SYSTEMS FOR DIVERSE AGROECOLOGIES AND PRODUCTION SYSTEMS

Entry Point	Specific Suggestions for capacity building and seed system innovation
Actor Orientation: A Vital and Complementary Perspective for Seed System Development	<ul style="list-style-type: none"> • Hold stakeholder forums involving the full range of actors for regular and open discussion on options for ensuring consistent availability and access to farmers of their preferred hybrid seeds. • Organize stakeholder forums to review seed and variety regulations and their implementation with involvement of diverse actors, including farmers. These forums should identify appropriate actions and facilitate actor buy-in. • Facilitate more interactions of different sorghum grain users and processors with other actors, including specific hybrid seed producers and growers, to open new opportunities for targeting specific grain markets. • More targeted interactions with ruminant livestock producers and researchers would be important to help capitalize on sorghum’s potential as a high quality fodder as well as grain crop.
“Farmer First” – A Necessary Perspective	<ul style="list-style-type: none"> • Continue and strengthen the focus on grain qualities for effective food yield, ease of preparation and nutritional quality of food preparations. • Recognize and enhance women’s capacity to produce and market sorghum grain for contributing to children’s food security, as for example by explicit efforts to enhance seed availability and access, possibly including biofortified varieties. • Give attention to farmer preferences for tall varieties with loose, drooping panicles for providing variety choice to farmers in the Sudan and Northern Guinea Savannah zones. • Emphasize cooperation among farmers and build on social norms for seed security as entry points for developing strategies to enhance seed dissemination and access dynamics.
Improved Collection and Sharing of Varietal Information and Performance Data	<ul style="list-style-type: none"> • Explore greater use of photos of varieties and their seed producers, as well as specific information derived from extensive farmer evaluations for marketing seed of new varieties, and share more widely the positive experiences seed cooperatives and their seed sellers have had with innovative communication methods. • Enable farmers, especially those who conduct variety evaluation trials, and their cooperatives, unions or groups, to <ul style="list-style-type: none"> ○ develop databases on varietal performance and farmers’ experiences with specific varieties over time, and ○ search for specific data, to revisit previous experiences, as well as learn from experiences of other farmers. • Facilitate farmer networking so that farmer cooperatives and groups can better communicate with researchers about new varieties and improved agronomic practices, and share information with other farmers in their communities. • Make data and varietal descriptions used for varietal release publicly accessible.
Strengthening Farmer Cooperatives and Their Networks	<ul style="list-style-type: none"> • Recognize that farmer seed-cooperatives produce the bulk of all certified OPV and hybrid sorghum seed in Mali, and are professional in producing seed of high quality, including hybrid parental seed; seek ways to respond to their desires for improving their <ul style="list-style-type: none"> ○ capacity and tools for seed processing. ○ financial and operational management skills. ○ capacity to sell their seed locally, and thereby “producing seed where it is needed” ○ skills with specific techniques for participatory variety development.
Integrate Plant Breeding as Part	<ul style="list-style-type: none"> • Document and share the experiences of the Malian sorghum breeder’s collaboration with farmer cooperatives on developing varieties and hybrids to serve as an example

of Seed System Development	<p>for integrating joint learning about variety performance and developing seed production and dissemination capacity simultaneously.</p> <ul style="list-style-type: none"> • Emphasize diversifying the portfolio of available varieties and hybrids as a priority for seed system strengthening, since seed system development hinges on improved performance and the specific production system advantages of new varieties.
Moving Resources From Control and Relief to Creativity and Resilience	<ul style="list-style-type: none"> • Free seed dissemination of sorghum should not be conducted with the intent of increasing availability of seed <i>per se</i>, as sorghum seed is almost always available except very rarely in remote areas in the driest Sahelian zone where it is not a major crop. • Explore options to subsidize seed certification (rather than seed <i>per se</i>) and decentralize seed certification, thus reducing price of seed and creating opportunities for enhanced collaboration between seed producers and inspectors.

MALI: MAIZE SEED SYSTEMS FOR DIVERSE AGROECOLOGIES AND PRODUCTION SYSTEMS

Entry Point	Specific Suggestions for capacity building and seed system innovation
Actor Orientation: A Vital and Complementary Perspective for Seed System Development	<ul style="list-style-type: none"> • Focus on adapting seed certification regulations so they can be implemented systematically, especially regarding field inspections. • Consultation among actors regarding variety release procedures and how they will be adapted to the regional ECOWAS seed laws. • Consultation among farmer seed-producer cooperatives and seed trade companies for better planning of seed production and dissemination across the maize production zones. • Consultation among traders, producers, breeders and food safety specialists to develop practices and capacity to reduce contamination of grain with aflatoxin and other fungal toxins.
"Farmer First" – A Necessary Perspective	<ul style="list-style-type: none"> • Develop capacity for seed production where it is needed, including capacity for seed storage. • Involve farmer cooperatives in maize variety and hybrid testing, thus helping to make more informed decisions for advancing given varieties for specific crop production conditions. • Build capacity for participatory breeding to reduce the time lag from variety development to large scale adoption.
Improved Collection and Sharing of Varietal Information and Performance Data	<ul style="list-style-type: none"> • Enhance availability of information about the advantages of specific new varieties and hybrids among maize producers, seed cooperatives, extensions services and other development actors. • Make data and varietal descriptions used for varietal release publicly accessible. • Enhance access of interested grain-marketing or seed-producer cooperatives to new varieties, hybrids, breeding materials for more widespread testing and evaluation under a wider range of production conditions.
Strengthening Farmer Cooperatives and Their Networks	<ul style="list-style-type: none"> • Develop capacity of seed cooperatives for producing seed of new OPV and hybrid varieties of maize. • Facilitate networking among cooperatives for maize seed dissemination. • Enhance local marketing capacity of maize seed producer cooperatives.
Integrate Plant Breeding as Part of Seed System Development	<ul style="list-style-type: none"> • Explore feasibility of private investment in maize hybrid-breeding to enlarge the portfolio of varieties commercially sold, since maize has larger and more homogenous marketing areas, with single varieties grown over large parts of the Sudan and Northern Guinea Savannah, as compared to any of the other staple cereals.
Moving Resources From Control and Relief to Creativity and Resilience	<ul style="list-style-type: none"> • Seek options for longer-term funding sources for maize breeding in Mali, as it is extremely reliant on short-term, project-based funding.



zef

Center for
Development Research
University of Bonn

Authors: Anja Christinck, Fred Rattunde, Alpha Kergna, Wellington Mulinge,
Eva Weltzien

Contacts: a.christinck@ditl.org; f.rattunde@gmail.com; a.kergna@yahoo.fr;
wellington.mulinge@kalro.org; eva.weltzien@gmail.com

Published by:
Zentrum für Entwicklungsforschung (ZEF)
Center for Development Research
Genscherallee 3
D – 53113 Bonn
Germany

Phone: +49-228-73-1861

Fax: +49-228-73-1869

E-Mail: presse.zef@uni-bonn.de

www.zef.de