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Identifying Options for the Development of Sustainable Seed Systems - Insights from Kenya and Mali



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Abstract

This paper results from a study that was commissioned to contribute to the Program of Accompanying Research for Agricultural Innovation (PARI)². The overall purpose was to propose an agenda for supporting sustainable development of seed systems in two Sub-Saharan countries, Kenya and Mali, based on the experiences and insights of seed system actors who contribute to various functions and operate at different scales.

The study relied on a mixed methodology, including (1) a desk review of secondary sources; (2) interviews with individual seed system actors and key informants; and (3) workshops in which diverse actors jointly discussed and prioritized options for sustainable seed system development. Staple cereal crops were targeted that are important for the farming and food systems of both countries: maize and sorghum for Kenya and maize, rice, sorghum and pearl millet for Mali.

In Kenya, most breeding for staple cereal crops is done by public breeding programmes, while some private breeding companies are also active. Seed production is mostly based on contracts between seed companies and large-scale farmers, while distribution is organized in the form of multi-level sales networks. In Mali, all breeding for staple cereal crops is done by public breeding programmes, with small farmer-managed seed enterprises being engaged in seed production and dissemination in their geographical areas. Collaboration between breeders and farmer cooperatives is extensive and crucial for the development and spread of new varieties, since the purchase of certified cereal seed by Malian farmers is quite a novelty. Limited choice of new varieties exists in both countries, particularly under conditions where climate variability and low soil fertility prevail. Furthermore, important quality and use-related traits are not systematically considered in breeding programmes. Slow and costly release procedures, limited availability of information about new varieties along with cash-flow constraints at various levels are factors that limit the dynamics of seed system development.

Differences in structure, organization and size of the seed markets in Kenya and Mali, and in various actors' contributions to seed system functions, lead to different outcomes in terms of quality, availability and access to seed. One important hypothesis for further discussion is that business models that include more decentralized models of seed production and distribution have comparative advantages for meeting the highly diverse demands of farmers in countries like Kenya or Mali, with a wide range of agro-ecological conditions and production systems, and could help reduce transaction costs. Furthermore, regulatory systems that provide space for a diversity of approaches for variety development, release, seed production and dissemination, are expected to be more supportive in this particular situation, compared with systems that focus on a narrow range of actors and variety types.

Important conclusions are that sustainable seed system development requires **more actor-orientation, with a central focus on farmers' capacities and needs**. Furthermore, **strengthening actors' capacities to collect, share and assess information** about varieties and their comparative performances will contribute to dynamic, responsive seed systems. **Plant breeding, as the source of value creation, needs to be regarded as an integral component of functioning seed systems** and requires joint consideration of what demands for innovations actually exist in order for seed systems to advance. **Decentralized seed production and marketing** enterprises can serve as nuclei for an emerging locally-based seed industry where market opportunities are limited and preferences diverse. 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.

Keywords: Seed system; human activity system; seed policy; seed system security; actor-orientation.

² <http://research4agrinnovation.org>

List of Abbreviations

ABSF	African Biotechnology Stakeholders Forum
ARIPO	African Intellectual Property Organization
BMZ	Federal Ministry for Economic Cooperation and Development
CBD	Convention on Biological diversity
CICR	Comité International de la Croix Rouge
CIMMYT	International Maize and Wheat Improvement Center
CMDT	Compagnie Malienne pour le Développement du Textile
CNSOV	Comité National des Semences d'Origine Végétal
COMESA	Common Market for Eastern and Southern Africa
CRS	Catholic Relief Services
DUS	distinctness, uniformity and stability
EAC	East African Community
ECOWAS	Economic Community of West Africa States
FAO	Food and Agriculture Organization of the United Nations
GDP	Gross Domestic Product
GeRRI	Genetic Resources Research Institute
GMOs	Genetically Modified Organisms
HDI	Human Development Index
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IITA	International Institute of Tropical Agriculture
IRRI	International Rice Research Institute
ISTA	International Seed Testing Association
ITPGRFA	International Treaty on Plant Genetic Resources for Food and Agriculture
KALRO	Kenya Agricultural and Livestock Research Organisation
KEPHIS	Kenya Plant Health and Inspectorate Service
MoALF	Ministry of Agriculture, Livestock and Fisheries
NBA	National Biosafety Authority
NGO	Non-governmental organization
NPTs	National Performance Trials
OAPI	Organisation Africaine de la Propriété Intellectuelle
OECD	Organisation for Economic Co-operation and Development
ON	Office du Niger
PARI	Program of Accompanying Research for Agricultural Innovation
QDS	Quality Declared Seed
SEWOH	'One World, No Hunger' initiative of the German Government
UNCDP	United Nations Committee for Development Policy
UNDP	United Nations Development Program
VCU	Value for cultivation and use
WAAPP	Western African Agricultural Productivity Promotion Table of Content

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1 Background and Objectives

Seed is a fundamental resource in agriculture, and of significant interest to farmers, seed and food industries, civil society and policy-makers worldwide. In many developing countries, government initiatives, supported by international organizations and donors, aim at transforming seed systems, mostly based on macro-economic rationales and considerations. This paper aims to complement this perspective by examining which changes or options for action the people who establish and maintain seed systems through their professional activities would suggest in order to make these systems more sustainable.

1.1 Background

This paper results from a study that was commissioned to contribute to the Program of Accompanying Research for Agricultural Innovation (PARI), which is a component of the German Government's 'One World, No Hunger' (SEWOH) initiative.

This initiative focuses on two key challenges: (1) To eradicate hunger and malnutrition, with a focus on those who are most vulnerable and worst affected; and (2) To create a framework to ensure that future generations will have sufficient, affordable and healthy food in spite of the rapidly expanding world population (BMZ, 2015).

'Modernization' of agriculture plays an important role for addressing these challenges, with seed being a critical entry point for enhancing value and productivity in agriculture. This is why it is in the focus of many agricultural policies and interventions, including in sub-Saharan Africa — mostly with a view towards creating 'enabling environments' for private sector investment in breeding and commercial seed marketing.

However, there is an ongoing debate on the benefits and costs of such seed system interventions. Our study was meant to contribute to this debate by exploring current and anticipated developments of seed systems for selected staple cereal crops from the perspective of 'actors on the ground', i.e. those who manage genetic resources; create varieties; produce, distribute and use seed; and to develop an agenda for sustainable seed system development based on their insights and priorities.

The study focuses on Kenya and Mali, countries situated in East and West Africa, respectively, representing highly contrasting contexts for breeding and seed systems. For example, Kenya was the first country in Africa to join the International Union for the Protection of New Varieties of Plants (UPOV) in 1999, and has considerably longer experience with building institutions and procedures related to formal variety testing, registration and release compared with West African countries, like Mali, which are currently in the process of adapting their institutions and procedures based on their obligations deriving from membership of regional organizations.

Moreover, Kenya has a long history in science-based plant breeding, with the first public maize breeding programme being established in 1955, resulting in the first release of a variety in 1961 and the first hybrid variety in 1964. A growing seed industry has developed in the country, focusing on a variety of crops, including cereals, oil crops, horticultural crops and Irish potatoes (Sikinyi, 2010).

The national maize breeding programme in Mali began operating later, with the first variety being released in 1972 and the first hybrid in 1984 (CIMMYT, 2015). Substantial engagement of researcher-led sorghum breeding occurred from the 1980s, and included collaboration with international organizations and initiatives, such as the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) (ABSF, 2010).

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 responding to the different contexts.

1.2 Study objectives

The overall purpose of this study was to propose an agenda for supporting sustainable development of seed systems in 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 focused on staple cereal crops, namely 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 the 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.

2 Approach and Methodology

Many studies on seed systems distinguish between ‘formal’ and ‘informal’ systems, with the former following more or less the model of an industrial supply chain, while the latter entail a range of mostly farmer-managed activities, e.g. to save, use, exchange and sell seed in local networks and markets (McGuire and Sperling, 2016).

However, the division of seed system actors and components into ‘formal’ and ‘informal’ categories appears 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*. In Mali, farmers increasingly engage in formal seed production and marketing, while local traders may offer seed from the formal sector alongside seed and/or grain from local sources.

Therefore, we propose a new approach to assessing seed systems — one that looks at various actors’ contributions to basic seed system functions, and how their activities, which are based on individual as well as collective goals, shape the outcomes (Long, 2001). Selected concepts and issues contributing to this new approach will be introduced in the following sections³, followed by a brief description of the methodology used.

2.1 Basic Concepts and Issues

2.1.1 *Seed System Functions*

Our attempt to avoid the limitations of dividing seed systems into ‘formal’ and ‘informal’ categories led 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 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).

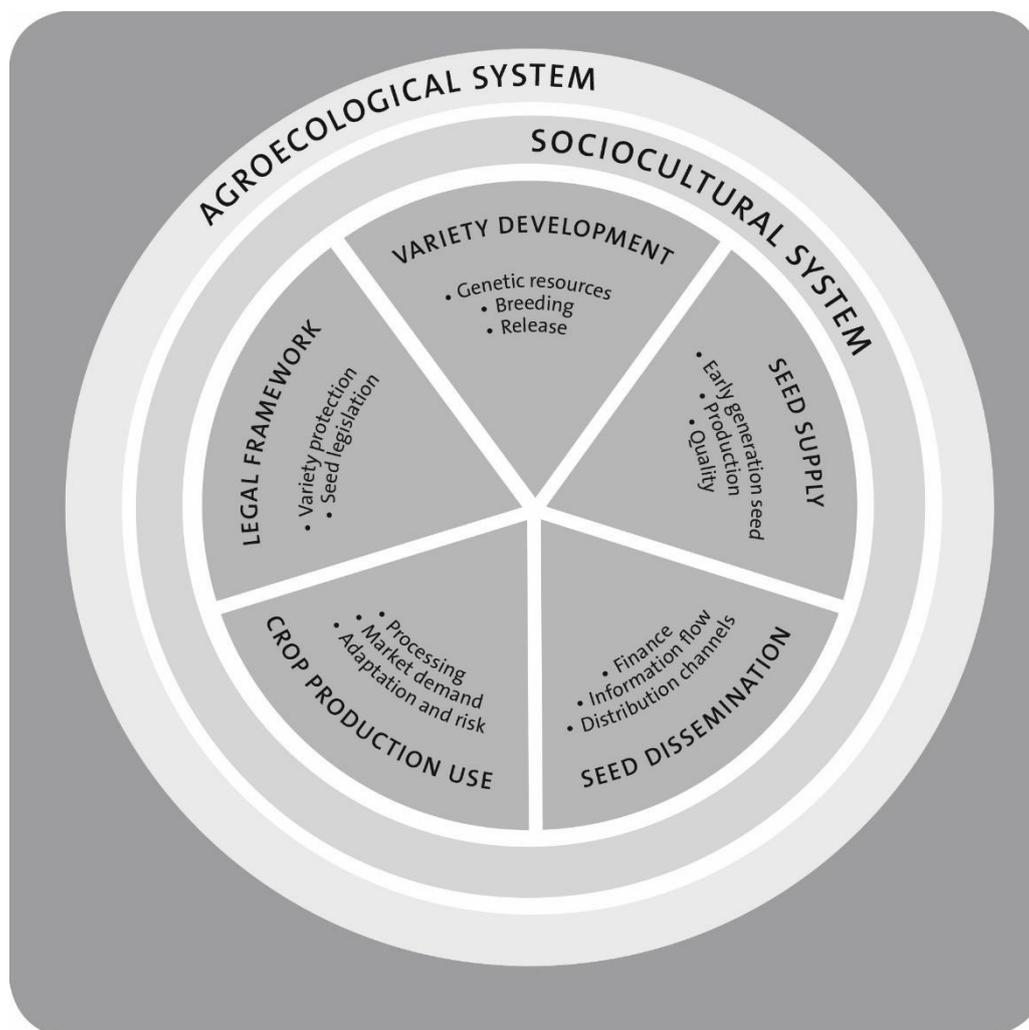
This perspective on seed systems helps us to see them as one system in which diverse actors pursue their individual goals and respective activities, while at the same time contributing to a collective purpose. Thus, the focus here goes beyond assessing the flow of seed, money and information, by emphasizing the role of actors for maintaining and enhancing seed systems, including the quality of relations among them. Thus, interventions that strengthen or challenge these relationships (e.g. benefits accruing to 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.

The basic seed systems functions we included in our assessment were: (1) provision of a legal framework; (2) variety development; (3) seed supply; (4) seed dissemination; and (5) crop production and use. These functions are seen to be embedded in specific socio-cultural and agro-ecological contexts (Figure 1).

We are aware that our proposition of seed system functions differs from what others might understand as core functions of a seed system. 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 each actor’s decision-making and thus the seed system’s overall functioning.

³ A more comprehensive description of theoretical issues that contributed to the development of this approach is presented by Christinck *et al.* (2017a).

Figure 1: Five basic seed system functions (centre), embedded in larger socio-cultural and agro-ecological contexts.



Source: Christinck *et al.* (2017a)

For example, the seed system’s legal framework has a large impact on the type of actors present and the products that can emerge from the system. By defining what ‘legal’ or ‘illegal’ actors, activities and products are, and clarifying roles, relationships and respective rights, its influence goes far beyond establishing quality standards or ensuring payments, even though this might be the stated objective.

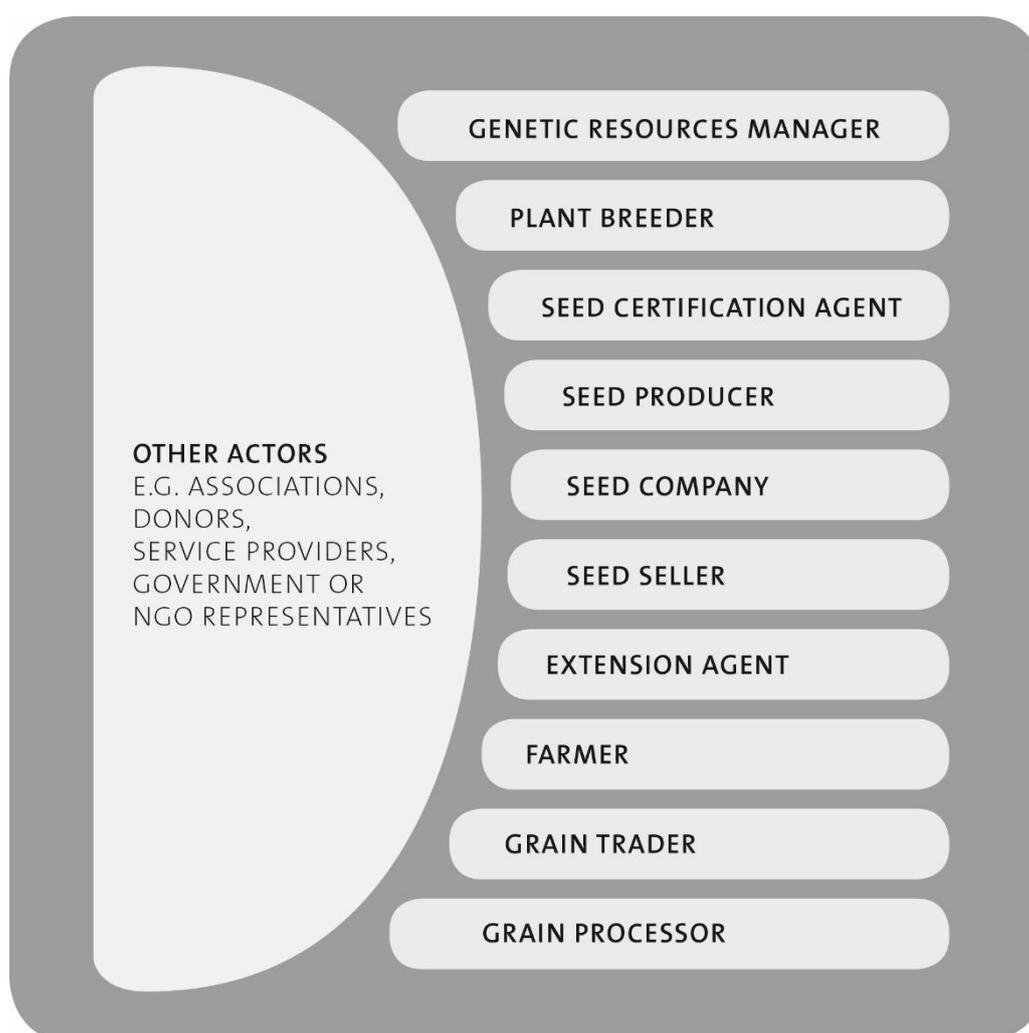
Variety development ‘nurtures’ the seed system by providing the basis for value creation at other levels. Seed supply and dissemination are of paramount importance to ensure that this potential can be fully tapped, and supports value creation ‘from farm to plate’ and beyond, e.g. by influencing nutritional and health status of individuals. 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 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.

‘Crop production and use’ is close to what is called ‘value for cultivation and use’ (VCU) in official variety release procedures, but aims to include the multiple types of value that staple crops may have for farmers in developing countries, and which are currently not fully covered by VCU test criteria.

2.1.2 Actor Categories

We identified different types of actors in the seed systems of the selected crops and study areas (see Section 2.2.1) 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 2). 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 2: Actor categories identified based on their contributions to seed system functions.



Source: Christinck *et al.* (2017a)

As different actor types may be involved in the same function, there are more actor categories than seed system functions. Extension agents are considered 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 operate independently, i.e. without contracts to produce for a specific entity, and sell seed directly to farmers, were included under the seed company classification rather than the seed producer category. Furthermore, 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.

2.1.3 *Seed System Security*

A sustainable seed system will ensure that high quality seed 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 (all) 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.

Seed system security, i.e. the degree to which seed systems can actually fulfil their basic function, is often assessed based on three aspects, namely (1) availability; (2) access; and (3) quality (Sperling, 2008; Sperling *et al.*, 2008).

Quality includes varietal traits (e.g. relating to environmental adaptation and use characteristics) as well as biological and technical seed quality (e.g. germination capacity, purity, etc.). 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 obtain seed, which can differ for different groups of people, depending, for example, on cash requirements or social relationships that may entitle an individual to obtain seed.

The seed system security framework, which was originally developed for better targeting of seed aid interventions (Remington *et al.*, 2002; Sperling and Cooper, 2003; Sperling, 2008), is used in this study to discuss the results and to identify strategic entry points for interventions and capacity building that support sustainable seed system development (see Chapters 5 and 6).

2.2 **Methodology Used**

In order to meet its objectives (see Section 1.2) the study employed a mixed methodology, including (1) a desk review of secondary sources; (2) interviews with individual seed system actors and key informants; and (3) workshops in which actors across categories discussed, identified and prioritized options for sustainable seed system development in their countries. Basic information on the methodology used is provided below, with a more detailed description being provided by Christinck *et al.* (2017a).

2.2.1 *Choice of Countries, Crops and Study Areas*

Kenya and Mali were selected, to study options for seed system development in contrasting contexts, as described in Section 1.1. In each country, a range of cereal crops were selected, that account for the majority of staple food consumed: in Kenya, maize and sorghum; and in Mali, maize, sorghum, pearl millet and rice.

For each country, study areas were selected based on existing administrative units ('counties' in Kenya and 'cercles'⁴ in Mali). Among these, areas with higher and lower adoption levels of 'modern' varieties were identified for each of the crops on which we focused, based on literature review and discussion with researchers from the cooperating national research institutes. Since 'adoption' is a result of a complex array of factors, the selected study areas vary in agro-ecological conditions and overall productivity levels, both being described in more detail by Christinck *et al.* (2017a). The study areas that were selected for Kenya and Mali, respectively, are presented in Table 1.

⁴ The term 'district' is used in this study as a translation of 'cercle' for improved readability.

Table 1: Study areas for studying seed systems of selected cereal crops in Kenya and Mali, representing high and low adoption levels of ‘improved varieties’ for each crop.

	Kenya		Mali	
	High adoption	Low adoption	High adoption	Low adoption
Maize	Trans Nzoia	Homabay	Sikasso	Koutiala
Sorghum	Homabay	Tharaka Nithi	Koutiala	Ségou
Pearl millet			Ségou	Mopti (upland)
Rice			Niono	Mopti (lowland)

(Christinck *et al.*, 2017a)

2.2.2 *Choice of Interview Partners and Workshop Participants*

We identified potential interview partners for each country, study region, crop and actor category (see Section 2.1.2) based on internet research, existing contacts, or contacts established as the fieldwork developed. Care was taken to include both actors with smaller- and larger-scale operations, and to include both genders where such factors were assumed to be relevant, particularly for seed producers and sellers, extension agents, farmers, grain traders and processors.

The workshop participants were selected from among the interviewed seed system actors, based on the following criteria: (1) coverage of the various actor categories, crops and study areas; (2) actors of both genders for relevant actor categories; and (3) individual ability to speak up, listen and share ideas, as well as capacity to understand a major workshop language (English in Kenya, French or Bambara in Mali).

2.2.3 *Methods Used for Interviews and Workshops*

Semi-structured interviews were used to explore the views and experiences of individual seed system actors of the above-described categories. Interview guides for each actor group were prepared beforehand by members of the study team, with a focus on (1) the interviewees’ activities and contributions to seed system functions; and (2) the interviewees’ experiences, including relationships with other actors, and suggestions for improvement. 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 percent). In Mali, 233 people were interviewed, of which 54 were women (23 percent). A complete list of interviews conducted for the purpose of this study is provided by Christinck *et al.* (2017a: Annex).

A preliminary evaluation of the interviews was done for the purpose of establishing a project 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 what suggestions for seed system improvement were made.

The workshops in both countries were designed in such a way that the purpose of the study and workshop were introduced and 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, establish a common ground, and obtain feedback.

Discussions on possible seed system interventions and improvements were then facilitated in a step-wise procedure within and across actor groups to jointly identify priority options for seed sector development⁵.

⁵ See Christinck *et al.* (2017a) for a more detailed description of methodologies used in interviews and workshops.

3 Results of Kenya Case Study

Basic information on Kenya's Agricultural and seed sector is presented in Section 3.1, followed in Sections 3.2 and 3.3 by a synthesis of interview and workshop results.

3.1 Basic Information on Kenya's Agricultural and Seed Sector

3.1.1 Basic Economic Information (Kenya)

Kenya is a multiethnic country having an estimated population of 46 million people, which increases by approximately one million per year⁶. *Per capita* Gross National Income (GNI) was 1,340 US-D in 2015; GNI had increased by about 26 percent 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 percent of the population lived below the poverty line in 2015, making Kenya one of the African countries with the largest populations living in extreme poverty, in spite of its economic growth (Karanja, 2015).

3.1.2 Importance of Agriculture and Selected Crops (Kenya)

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

At the same time, 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 imports to the country have shown notable annual fluctuations for maize and wheat, whose domestic consumption is much higher than for rice and sorghum.

Maize is by far the most important staple cereal in Kenya, grown on slightly more than 2 million ha annually and total annual production about 3.5 million tonne in recent years (average of years 2010–2014, FAOSTAT⁷ 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 tonne and yield levels of around 0.75 t/ha (average of years 2010–2014, FAOSTAT data).

Compared with 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 that of sorghum nearly threefold (244–312 percent), whereas in Homabay County they differed only by 6 to 20 percent in the same 2012–2014 period⁸. Production conditions also vary within counties, such that, in individual farmers' fields with unfavourable moisture or fertility conditions, sorghum can yield more than maize.

⁶ <http://www.worldbank.org/en/country/kenya/overview> (22 April 2017)

⁷ <http://www.fao.org/faostat/en/> (15 December 2016)

⁸ Calculated based on data provided by MoALF (2016)

3.1.3 *Regulatory Framework for Kenya's Seed Sector*

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 Protocol⁹, which was adopted by member states in 2015, but has so far not entered into force.

However, Kenya has already 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.

The Seeds and Plant Varieties Act 1972 (last amended 2012) establishes the basic rules for variety registration and plant breeders' rights. It mandates the Kenya Plant Health and Inspectorate Service (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 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. 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) Regulations¹⁰. 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).

3.1.4 *Structure and Estimated Size of Kenya's Maize and Sorghum Seed Market*

With a total maize production area of 2 million ha (see above), the amount of maize seed required for sowing would be around 40,000–50,000 tonne, based on sowing rates of 20–25 kg/ha. For sorghum,

⁹ <http://www.aripo.org/resources/laws-protocols/member-states-copyright-legislation-6> (15 January 2018)

¹⁰ <http://www.wipo.int/edocs/lexdocs/laws/en/ke/ke011en.pdf> (22 April 2017)

with 0.2 million ha, the seed required annually for sowing would be around 1,000–1,600 tonne (based on 5-8 kg/ha). The data presented in Table 2 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.

Table 2: Amounts of locally produced and imported certified seed (tonne) available in Kenya for the period 2006/2007 to 2016/2017

	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

(Data kindly provided by KEPHIS for the purpose of this study)

However, these figures provide only an estimate of the amount of certified seed that is actually used by farmers, since Kenya also exports seed, for example 2,761 tonne of maize seed and 151 tonne 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 tonne), minus exported seed, we estimate that the amount of certified maize seed available in Kenya totaled 30,682 tonne in 2015/16. This quantity would be sufficient for sowing around 60 percent of the cultivated area of this crop (based on 25 kg /ha). The estimated amount of certified sorghum seed available in Kenya (628 tonne domestic, imported, plus recertified seed sampled minus exported seed) was 477 tonne in 2015/16, sufficient for sowing 30 percent of the area sown to this crop (based on 8 kg/ha)¹¹. 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 percent for maize and 70 percent 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 of Kenya’s seed industry (AgriExperience, 2012); these companies traded in seed of cereals, oil crops, pulses, pastures, fruits and vegetables — mostly crops that also dominate research in relevant public institutions (Misiko *et al.*, 2011).

A specific feature of Kenya’s seed market is that one parastatal company, KSC, holds a market share of about 70–80 percent, mainly based on one hybrid variety of maize (H 614) and one wheat variety

¹¹ All figures in this paragraph are calculated based on information provided by KEPHIS (2016).

(‘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).

Hence, although the number of seed companies in Kenya has increased, their presence and market shares are limited compared with KSC. For the entire seed market, not focusing on maize alone, AgriExperience (2012) represents Pannar (based in South Africa), SeedCo (based in Zimbabwe), Monsanto and Pioneer (both multinational companies) as ‘key players’ besides KSC. For hybrid maize, 83 percent of all hybrid maize growers planted seed marketed by KSC, according to a survey conducted in 2010. The remaining 17 percent of hybrid seed planted was from private companies — including, in order of greater frequency, Western Seed, Pioneer, Monsanto, Pannar, Agriseed, Lagrotech and Faida (Smale and Olwande, 2014).

3.1.5 Seed Aid (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.

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.

3.2 Interview Results (Kenya)

The most important results from interviews with individual seed system actors are summarized here (Table 3) according to the five basic seed system functions introduced in Section 2.1.1 (Figure 1).

Table 3: Summary of information provided by seed system actors in Kenya in relation to seed system functions (differentiated by actor categories if applicable)

Actors’ contributions and perspectives on seed system functions	
Legal framework (Variety protection and seed legislation)	<ul style="list-style-type: none"> • Variety release procedures required for legal seed marketing are well established and work in general. • They add high costs in terms of time delays and funds needed to apply. • They conflict with small-scale farmers’ interest in accessing seed of specific local varieties, including on a commercial basis.
Variety development (Genetic resources, breeding and release)	<ul style="list-style-type: none"> • Farmers manage a range of local maize and sorghum varieties, on their own and with support from NGOs, mainly because of preferred adaptive and use-related traits. • Selection in both local and purchased seed of maize and sorghum is a widespread practice. • KALRO¹²’s Genetic Resources Research Institute (GeRRI) manages collections of maize and sorghum genetic resources originating from Kenya and cooperates with international genebanks (e.g. ICRISAT); it is also involved in activities that address <i>in situ</i> conservation and use of local germplasm, targeting nutritional quality and marketing activities.

¹² Kenya Agricultural and Livestock Research Organisation (KALRO; www.kalro.org)

	<ul style="list-style-type: none"> • Science-based plant breeding for both crops is mostly done by public breeding programmes (e.g. KALRO's Field Crops Institute), partly in cooperation with international research centres (ICRISAT for sorghum, CIMMYT¹³ and IITA¹⁴ for maize); these activities often depend on short-term project funding. • Private breeding is done for maize in Kenya by the domestic company Western Seed Co.; other regional or multinational breeding companies get varieties developed elsewhere through the release process to market seed in Kenya. • Results of National Performance Trials (NPTs) are considered 'sensitive' and are not publicly available.
<p>Seed supply (early generation seed, seed production and seed quality)</p>	<ul style="list-style-type: none"> • Early generation seed of publicly bred varieties and hybrids is produced by KALRO's own seed unit; it also produces seed of new varieties and of crops private seed companies are not interested in. • Early generation seed of varieties developed by private companies is produced by these companies or under their close supervision (based on contracts with farmers). • Licensing policies for marketing seed of varieties developed by the public sector (and related processes) are not fully transparent and cause prolonged negotiations and delays. • Seed is produced by farmers for their own use, and on a commercial basis by KALRO's seed unit and registered private companies. • Companies usually have their seed produced by contracting individual large-scale farmers or groups of large-scale farmers. • The companies usually have one central hub, to which all seed is transported for processing and packaging. • Sorghum seed is also sometimes produced and processed by groups or cooperatives of small-scale farmers (e.g. in Homabay County) on a contract basis. • All certified seed in Kenya is chemically treated. • The entire process for the production of certified seed is controlled by KEPHIS. • Most farmers reported having received supposedly certified seed that had poor germination capacity.
<p>Seed dissemination (distribution channels, information flow, finance)</p>	<ul style="list-style-type: none"> • Seed dissemination pathways in Kenya are diverse and often involve several actors, e.g. (large) distributors, agrodealers and seed sellers ('agrovets' or 'stockists'). • The latter sell seed alongside other farm inputs, such as animal feed and veterinary products, which tend to have a higher priority since they can be sold throughout the year. • Other dissemination pathways include associations and village-based networks, e.g. facilitated by NGOs, as well as seed distribution through large-scale grain traders aiming to ensure their supply with grain of adequate quality and quantity, local grain markets for specific local varieties, and free seed distributions. • Some seed companies offer advantages to agrodealers and stockists who sell exclusively seed from this company. • Farmers reported difficulty in obtaining seed of their preferred varieties. • Information on varieties and seed is spread through seed sellers and other farmers, as well as activities such as field days or demonstration plots. However, small-scale farmers and women in particular reported that they had never been invited to such activities, or that they were too far away to deliver relevant information for them. • There is a widespread desire of farmers to get more relevant varietal information, e.g. from growing test plots.

¹³ International Maize and Wheat Improvement Center (CIMMYT; www.cimmyt.org)

¹⁴ International Institute of Tropical Agriculture (IITA; www.iita.org)

	<ul style="list-style-type: none"> • Various actors, including seed sellers, extension agents, NGO representatives and farmers stated a lack of comparative results on varietal performance or profitability. • Limited cash availability was mentioned as a challenge by farmers and seed producers. • For farmers, cash availability and seed prices influenced their choice of varieties, along with other criteria.
<p>Crop production and use (adaptation, grain processing quality, market demand)</p>	<ul style="list-style-type: none"> • Varietal adaptation to agro-ecological and low-input production conditions was a high priority for most farmers and influenced their choice of varieties. • The turnover of varieties is low, so that breeding progress achieved does not reach farmers' fields, or after long delays. • Grain quality is an important reason for farmers cultivating 'old' varieties/hybrids or local varieties rather than new ones perceived to have lower grain quality, e.g. lower flour yield, more risk of storage losses and taste and texture issues that are important for grain that is used in principal dishes. • Women farmers mentioned quality traits more frequently as a reason for preferring specific varieties than men and/or described them in more detail. • Although local varieties and modern bred-varieties were cultivated across all sites, often by the same farmers, local varieties gained importance for smallholder and especially for women farmers. • Approximately half of the women interviewed reported growing only local varieties of maize, whereas all men interviewed grew modern maize varieties. • Grain mold and aflatoxin contamination as well as storability of grain and post-harvest losses are also a major concern of grain traders. • The market for white sorghum grain created by East African Breweries Ltd. is clearly being responded to by farmers in both Tharaka Nithi and Homabay Counties; the few commercially available sorghum varieties were mostly white-grained, while grain prices in local grain markets were often higher for local varieties which were predominantly red-grained.

(Based on Christinck *et al.*, 2017a)

3.3 Workshop Results (Kenya)

The 18 workshop participants (14 men and four 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 3.2 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.

During the first session, actors from the same location (county) discussed the suggested improvement options for relevance in their local contexts, and further amended and specified proposed actions. The second discussion session was organized in a way that actor groups discussed and further developed options that were suggested for this group in the previous section.

Important suggestions made in the first and second discussion sessions are summarized in Table 4.

Table 4: Seed system development options suggested by discussion groups formed based on study areas (Session 1) and actor groups (Session 2) during a workshop with seed system actors in Kenya.¹⁵

	Session 1
Trans Nzoia County	<ul style="list-style-type: none"> • Clarify roles of government/parastatal and private sector companies. • Create more transparency regarding data generated by state agencies, e.g. NPTs. • Explore alternatives to current certification process, e.g. voluntary certification, QDS system.¹⁶ • Increase the number of selling points for seed and other agricultural inputs.
Tharaka Nithi County	<ul style="list-style-type: none"> • Facilitate access to seed for experimental purposes and offer small seed packages. • Improve the quality of information and feedback among seed system actors. • Train local groups for seed production and encourage new groups to improve availability of seed of preferred varieties close to farmers. • Improve seed quality by post-certification monitoring, improved packaging and seed companies recalling unsold seed. • Maintain local varieties and enhance farmers' skills in selection and seed production of these varieties.
Homabay County	<ul style="list-style-type: none"> • Make a joint effort to develop/diversify the market for sorghum and sorghum-based products. • Better organize and target free seed distributions in a transparent manner and channel it through seed sellers. • Improve communication and trust between seed producers and contracting companies. • Organize seed production in a more decentralized manner to reduce costs. • Improve cooperation between extension agents and farmers to improve capacities for seed selection and production, integration of varietal choice and other production measures and information exchange. • Encourage youth groups to engage in group-based seed and grain production.
	Session 2
Farmers	<ul style="list-style-type: none"> • Enhance capacities for sharing information on variety and seed issues. • Improve farmers' skills in variety testing and choosing varieties. • Use IT-tools to exchange experiences with others about specific varieties and agronomic practices.
Plant breeders, seed companies and KEPHIS	<ul style="list-style-type: none"> • Breed varieties with specific traits and attributes. • Improve public access to information (e.g. from KEPHIS). • Deliver quality seed to farmers more swiftly (e.g. by exploring options such as QDS).
Extension agents, NGO representatives and agrodealers	<ul style="list-style-type: none"> • 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.

¹⁵ A more comprehensive description of suggestions made by different actor groups is presented by Christinck *et al.* (2017a).

¹⁶ Quality Declared Seed (QDS) refers to a system that make use of resources seed producing organizations have in place as an alternative to certification, based on agreed-upon guidelines and standards (FAO, 2006).

The final discussion took place in the plenary and included joint priority setting based on the three top priorities each group had identified in the second session. The result is presented in Table 5.

Issues with more contentious viewpoints included the roles of parastatal and private sector companies, and how both could take on a complementary role. Smaller sized seed packages were clearly demanded but seed industry representatives stated that packaging seed into small units added cost, thus making this option untenable, except with large orders from NGOs. Likewise, the suggestion to return unsold seeds was contentious regarding the distribution of responsibilities and costs among actors.

Furthermore, some participants indicated missing a stronger focus on farmer-managed seed system activities and their recognition in legal frameworks. Diverging views were expressed concerning the quality of newly bred varieties with regard to adaptation and grain quality traits. Farmers in particular were interested in getting more involvement in varietal selection and seed production, while other participants preferred the current status.

Table 5: Priorities set jointly among options for seed system improvement by seed system actors in Kenya

Priority no.	Options for seed system improvement
1	<ul style="list-style-type: none"> Organize county stakeholder forums on seed system issues.
2	<ul style="list-style-type: none"> Breed varieties with special attributes.
3	<ul style="list-style-type: none"> Enhance farmers' capacities for information sharing on variety and seed issues.
4	<ul style="list-style-type: none"> Conduct trainings on variety and seed issues for farmer groups and agrodealers.
5	<ul style="list-style-type: none"> Deliver good quality seed more swiftly.
6	<ul style="list-style-type: none"> Improve information exchange among actors.
7	<ul style="list-style-type: none"> Improve public access to information.
8	<ul style="list-style-type: none"> Improve farmers' skills for variety testing (experiential assessment).
9	<ul style="list-style-type: none"> Use ICT¹⁷-tools for farmers' exchange of experiences on varieties and agronomic practices.

(Based on Christinck *et al.*, 2017a)

¹⁷ Information and Communication Technology/ies

4 Results of Mali Case Study

Basic information on Mali's Agricultural and seed sector is presented in Section 4.1, followed by a synthesis of interview and workshop results in Sections 4.2 and 4.3.

4.1 Basic Information on Mali's Agricultural and Seed Sector

4.1.1 *Basic Economic Information (Mali)*

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 percent p.a.), with increases of approximately one million people every two years¹⁸.

Most of Mali's people live in the southern parts of the country; only 10 percent live in the three northern regions of Gao, Kidal and Timbuktu¹⁹. Per capita GNI was USD 760 in 2015 (Atlas method)²⁰; 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, INSTAT, estimates that 47 percent 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).

4.1.2 *Importance of Agriculture and Selected Crops (Mali)*

Agriculture is a cornerstone of Mali's economy, with 80 percent of the population being engaged in agricultural activities, including livestock and fisheries. In 2015, the agricultural sector accounted for 40 percent of the country's GDP²¹, with dryland cereals, rice, livestock and cotton being the most important agricultural products. Raw cotton accounted for 20 percent of Mali's exports (by monetary value) in 2015, while oilseeds, tropical fruits, animals and live-stock products together accounted for another 10 percent, approximately.

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 tonne per year, and for sorghum between 0.8 and 1.2 million tonne per year, depending on agroclimatic conditions. Average yield levels are 0.86 t/ha for pearl millet and 0.93 t/ha for sorghum (averages of years 2010–2014, FAOSTAT data).

Maize and rice are grown on a smaller area (maize: 0.7 million ha; rice: 0.6 million ha, average of years 2010–2014, FAOSTAT data) but, given more favourable production environments, 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) and maize (1.5 million t/year; averages 2010–2014, FAOSTAT data) exceeds annual pearl millet and sorghum grain production in most years, particularly for rice. Rice production in Mali has continued to increase in recent years; production in 2014–2016 is estimated to have reached around 2.3–2.7 million tonne.

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

¹⁸ <http://www.worldometers.info/world-population/mali-population> (25 April 2017)

¹⁹ <http://www.worldbank.org/en/country/mali/overview> (25 April 2017)

²⁰ <http://data.worldbank.org/country/mali> (25 April 2017)

²¹ <http://data.worldbank.org/indicator/NV.AGR.TOTL.ZS?locations=ML> (25 April 2017)

exported, though in small quantities (between 71 to 322 tonne 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 2009–2013 (FAOSTAT data).

4.1.3 *Regulatory Framework for Mali's Seed Sector*

Mali is a member of ECOWAS and of the African Intellectual Property Organization (Organisation Africaine de la Propriété Intellectuelle, OAPI). 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 states²². 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.

The Seed and Plant Variety Act (Loi 10-32 (2010) relative aux semences d'origine végétale²³) 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 at present no system for collecting royalty fees.

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

Seed distribution, including seed import and export, are also regulated under the Seed and Plant Variety Act. These activities require 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 Biotechnologie²⁴ (2008)).

Until recently, varieties were registered in the National Variety Catalogue through a simple process, whereby the breeder prepared and submitted a technical data sheet summarizing details of origin, pedigree and traits of importance for the crop. Nowadays, 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 and schedule field visits to evaluate the variety over three years. Each field visit is to be reported. 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 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

²² According to an UPOV press release, available at:

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

²³ <https://mali.eregulations.org/media/DNA%20Loi%20n%2010-32.pdf> (19 December 2016)

²⁴ <http://faolex.fao.org/docs/pdf/mli152165.pdf> (18 December 2016)

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 and includes the following steps: production of breeders' seed and foundation seed, usually by the breeder; followed by two generations of certified seed (R1 and R1).

The official procedure for seed certification includes: registration of seed producer; prior notification of variety; location; area of production; etc.; three field inspections (before, during and after flowering of the crop); sampling; laboratory analyses; and treatment and labelling of accepted seed lots. In practice, however, the registration of seed producers and the treatment of accepted seed lots are currently not demanded. Also, the number of field visits often is less than three.

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.

4.1.4 Structure and Estimated Size of Mali's Seed Market

The production areas for sorghum, pearl millet, maize and rice in Mali, along with recommended seed rates, are used here for calculating the estimated size of seed markets for these crops in Mali (Table 6).

Table 6: 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

	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

(Cultivated area: average of years 2010–2014, FAOSTAT data; amount of certified seed available: Ministère de l'Agriculture (2016))

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, compared with 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 currently is estimated to account for approx. 5 percent of the seed sown for sorghum and pearl millet crops, and for approx. 10–15 percent 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.

The national seed laboratory indicates that the amount of certified seed in the last 5 to 6 years, following implementation of the 2010 seed legislation, increased by more than 60 percent for rice and maize, and by more than 600 to 800 percent for sorghum and pearl millet²⁵. 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.

²⁵ No published data available; information was kindly provided by the national seed laboratory.

For the entire Malian seed sector, including all crops, it is estimated that around 80 percent 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 the country (Diallo and de Boef, 2012).

Agrodealers and emerging private seed companies mostly market seed they obtain, after certification, from farmer cooperatives or groups, generally without prior contracts. NGOs and government institutions purchase certified seed from cooperatives or seed companies for distribution to their target groups. Some individual grain traders 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. Furthermore, 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 cooperation between them and public breeding programmes, NGOs, traders or private seed companies. Furthermore, 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.

4.1.5 *Seed Aid (Mali)*

The Malian Government actively supports agricultural production, with about 15 percent of the total budget²⁶ (47 billion FCFA, equivalent to approx. USD 84.9 million) being allocated 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). Some years ago, the Malian government also subsidized seed of NERICA²⁷ 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) programme 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 tonne of free seed (free) in each of the recent years; FAO distributed smaller amounts, between 15 tonne (cowpea) and 155 tonne (rice) within the last five years, and the CICR distributed 13.3 tonne in 2015 and 6.8 tonne in 2016.²⁸ Hence, WAAPP/WASP was by far the largest supplier of 'free seed' in Mali in recent years; an important share of the certified seed that has been produced in recent years was not sold, but distributed by these organizations.

²⁶ <http://www.librefrique.org/kramo-subventions-mali-010716> (28 July 2017)

²⁷ 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).

²⁸ There are no published sources for these figures; information was obtained from the organizations' offices in Mali.

4.2 Interview Results (Mali)

The most important results from interviews with individual seed system actors are summarized here (Table 7) according to the five basic seed system functions introduced in Section 2.1.1 (Figure 1).

Table 7: Summary of information provided by seed system actors in Mali in relation to seed system functions (differentiated by actor categories if applicable).

Actors' contributions and perspectives on seed system functions	
<p>Legal framework (Variety protection and seed legislation)</p>	<ul style="list-style-type: none"> • The national and regional variety catalogues and the variety release process are established in general, but with some need for clarification of roles and responsibilities. • Some breeders fear that the new procedure requiring DUS and VCU trials will prove more costly and time consuming. • Local varieties cannot be registered under the new regulations, and thus their seed cannot be certified for sale even when farmers demand this seed. • The seed certification procedure causes additional costs and delays; even though only a minor share of the seed used in Mali is at present certified, resources are lacking to implement the certification process as officially required, or in a timely manner. • Not all certified seed is labelled, so that farmers cannot know in all cases if the seed they buy is certified or not.
<p>Variety development (Genetic resources, breeding and release)</p>	<ul style="list-style-type: none"> • Genetic resources are managed by the Institut d'Économie Rurale (IER), in collaboration with CG-Centers (e.g. CIMMYT and IITA for maize, IRRI²⁹ and African Rice Center for rice). • The IER maintains science-based breeding programs for all four crops; a recent achievement in sorghum and pearl millet breeding is hybrids that are based on open-pollinated varieties (OPVs) and local germplasm. • Breeding goals include improved adaptation and yield, nutritional quality, resistance against diseases and <i>striga</i> (a parasitic weed) and fodder quality. • All breeding activities are highly dependent on short-term project funding. • Farmer participation is widespread, e.g. for joint evaluation of breeding materials and varieties. • 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 for all cereal crops of adaptation to low soil fertility in Mali. • The additional costs and delays caused by the new variety release process were frequently mentioned by breeders.
<p>Seed supply (early generation seed, seed production and seed quality)</p>	<ul style="list-style-type: none"> • Certified seed in Mali is almost entirely produced by farmer seed-producer groups. These groups include associations, cooperatives and Groupes d'Intérêt Économique (GIEs), a Malian specific legal business entity. • Early generation seed is usually supplied to seed producers by the public breeding programmes; 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. • 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 cross-pollinating crops, due to the smaller size of their fields combined with low soil fertility. However, there was also one successful women's seed-cooperative producing

²⁹ International Rice Research Institute (IRRI; www.irri.org)

	<p>large seed volumes of many varieties of rainfed (lowland) rice; a crop traditionally considered to be a women’s crop in Mali.</p> <ul style="list-style-type: none"> • There are two predominant models for conditioning and packaging seed in Mali. Either centralized with imported high-capacity equipment (mainly seed companies); or geographically decentralized with predominantly manual methods (mainly farmer-managed cooperatives). • Poor germination capacity and mixed or fake seed were rarely mentioned by farmers; the only exceptions were complaints regarding varietal purity for rice seed, and problems with germination capacity in seed received via free seed distribution activities.
<p>Seed dissemination (distribution channels, information flow, finance)</p>	<ul style="list-style-type: none"> • Farm-saved seed is the most common source of seed for all cereals. • Commercial dissemination of certified seed is a new and evolving undertaking for most staple cereals (except for rice). • If seed is purchased, the most common dissemination pathways is direct from known farmer-managed seed cooperatives. • Further distribution pathways include cooperative representatives that sell seed on commission in several villages; sales through or with assistance of NGOs and the regional department of agriculture; by agrodealers who purchase the cooperatives’ seed for sale from their shops; and direct seed distributions. • Information is spread through radio programmes, participation of farmers in variety evaluation trials, seed fairs, demonstration plots etc. However, it requires large and continuing efforts to spread varietal information and information on selling points to interested farmers. • Challenges of cash flow constraints were mentioned, particularly by farmer seed-producer groups and farmers. Farmers’ challenges were addressed through price differentiation as well as sale on credit basis, e.g. by unions of farmers’ cooperatives who primarily engage in cooperative grain marketing.
<p>Crop production and use (adaptation, grain processing quality, market demand)</p>	<ul style="list-style-type: none"> • Adaptation to local agro-ecological conditions and in some cases tolerance of biotic stresses were important criteria guiding farmers’ varietal choices. • Unacceptable grain or fodder quality can lead to rejection of new, ‘improved’ varieties, in spite of higher yields. • Some specific market demand exists, e.g. for grain colour of maize used for poultry feed, or for taste and grain shape of rice. Such preferences are mostly reflected in prices paid for grain of desired quality.

(Based on Christinck *et al.*, 2017a)

4.3 Workshop Results (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. 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. These included options for improving infrastructure and equipment, financial and organizational support, strategic approaches, as well as options relating to improved information and access to seed.

The first round of discussions were conducted by six groups of participants, with two groups each per crop or crop group/agro-ecology (rice, sorghum and maize, and pearl millet). The task for one group per crop (groups 1 to 3) was to identify priority options for improving availability of good quality seeds in proximity to farmers, whereas the other group (groups 4 to 6) considered options for enabling

adoption of these varieties. Important suggestions made in the first discussion session are summarized in Table 8.

Table 8: Seed system development options suggested by discussion groups formed based on crops/agro-ecologies for improved availability and adoption of improved seed.³⁰

	Session 1a: Suggestions for improving availability of seed of improved varieties close to farmers
Group 1 (focusing on rice)	<ul style="list-style-type: none"> • Ensure availability of sufficient early generation seed. • Initiate stakeholder forums among seed cooperatives and partners for enhancing information diffusion. • Identify needs to better plan seed production.
Group 2 (focusing on sorghum and maize)	<ul style="list-style-type: none"> • Produce seeds where they are needed. • Increase the number of selling points. • Build seed storage facilities.
Group 3 (focusing on pearl millet)	<ul style="list-style-type: none"> • 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.
	Session 1b: Suggestions for facilitating adoption of improved variety seed
Group 4 (focusing on rice)	<ul style="list-style-type: none"> • Strengthen 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)	<ul style="list-style-type: none"> • Organize demonstration plots and farmer field schools. • Strengthen participatory plant breeding. • Organize visits to breeders' fields for seed sellers.
Group 6 (focusing on pearl millet)	<ul style="list-style-type: none"> • 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 options identified for improving seed availability 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. Group 6, focusing on facilitating adoption of improved varieties of millet, emphasized that the major weakness in the pearl millet seed system was the absence of improved varieties for diffusion, at least for a sufficient diversity of agro-ecological zones.

The second discussion session focused on options for ensuring or enhancing seed quality, based on the expressed wish of participants. Women participants insisted on having their own discussion group for this topic, while men divided into two groups.

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. The second men's group focused on the same topics and suggested that transparent norms should be established for production and certification of good quality seed. 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

³⁰ For a more comprehensive description of suggestions made by different actor groups, please consult the project report (Christinck et al. 2017a).

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, and strongly favoured self-control over certification.

The women’s presentation of their propositions 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, were debated with such emotional intensity that it was decided that further interactions were needed on this topic of obvious concern and tension.

Hence, in the final session, workshop participants discussed activities that had been proposed in the first session to identify specific seed system development options that were of highest priority to all participants (Table 9).

Table 9: Priorities among options for seed system improvement set jointly by seed system actors in Mali.

Priority no.	Priority options for seed system improvement
1	<ul style="list-style-type: none"> • Initiate stakeholder forums at various levels, e.g. for improved planning among seed producer cooperatives, among these cooperatives and breeders, as well as among seed producer cooperatives and financial service providers.
2	<ul style="list-style-type: none"> • Enhance capacities of seed producer cooperatives regarding participatory breeding and variety evaluation, seed production and processing as well as financial and operational management.
3	<ul style="list-style-type: none"> • Enhance capacities of agrodealers regarding their knowledge of varieties, regarding communication and marketing of seed, and in building links between seed producers, farmers and grain processors.

5 Discussion of Results

The findings of our study, presented in Chapters 3 and 4 for Kenya and Mali, respectively, are discussed here in relation to the three aspects of seed system security: seed quality, seed availability and access to seed, which were introduced in Section 2.1.1. This discussion is presented in Sections 5.1–5.3, followed by a discussion of cross-cutting issues in Section 5.4. The diverse issues brought out in this discussion emerge primarily from the experiences and visions of the diverse actors, documented in interviews and workshops, and are extended based on the study team members' experience, and published literature.

5.1 Seed Quality

The 'raison d'être' of any seed system is provision of seed of value to the user, as indicated by the use of terms such as 'improved seed' or 'quality seed'. 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.

5.1.1 Varietal Attributes

Varietal attributes, such as improved yield or use-related traits, are the main potential source of value creation through the use of seed of certain varieties. 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 percent sold maize (Smale and Olwande, 2014).

The quality of maize grain for food was found to be a key varietal attribute farmers consider when choosing their maize variety in Kenya, 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, even though the breeding of new varieties with good grain quality is certainly feasible, with abundant genetic variation for quality-related traits. For example, the local varieties that farmers cultivate and appreciate could be a prime source.

Secondly, 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. 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). Furthermore, adapted hybrids, with advantages of hybrid vigour, 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.

5.1.2 Varietal Diversity

A further important issue related to a seed system's ability to provide seed of preferred quality is the level of varietal diversity it offers. In this study, farmers interviewed in Kenya and Mali reported growing several different varieties of the same cereal species. Farmers also reported cultivating both bred and local varieties, including 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), and similarly in Burkina Faso (Barro-Kondombo *et al.*, 2008).

Furthermore, varieties with novel or specific traits can offer new options for producing or using crops, to farmers and their market partners. Examples include earlier maturing varieties enabling relay cropping (e.g. reported by women maize producers in Kenya), or capturing higher grain prices prior to the general harvest (e.g. sorghum in Mali); or novel dual- and multi-purpose sorghum varieties 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).

5.1.3 *Biological and Technical Seed Quality Aspects*

Lastly, for a seed system to function, biological and technical seed quality aspects need to be ensured. Otherwise, trust among actors will be undermined and production risks increase. Government agencies are rejecting seed lots based on criteria established for seed quality in both Kenya and Mali. It thus seems that these regulations and controls aim to contribute to reducing the frequency of occurrence of commercially traded seed with low germination capacity and off-type plants.

The occurrence of poor seed germination was, however, an issue in Kenya, both for certified and farmer-saved, own seed, whereas it was not an issue of concern for either type of seed in Mali. Furthermore, 'fake seed' was an issue in the Kenya seed market, whereas there were no reports of 'fake seed' in the Malian commercial seed market, although serious cases were reported for seed that was received through direct seed distribution.

These results are surprising since Kenya has an elaborate regulatory system and highly professional control agency, yet the seed control system in Mali is far weaker in comparison. However, the presence of 'fake' seed, or seed with low germination capacity, was also reported by other researchers for the Kenyan seed market (Karingu and Ngugi, 2013; Tjernström *et al.*, 2017). This paradox strongly suggests that factors other than the legal control system need to be examined for their role in affecting good seed germination and trueness to type.

One important 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. Furthermore, certified seed in Mali is usually not chemically treated, allowing seed-producer cooperatives to sell left-over stocks as grain. 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.

Furthermore, besides applying existing control options, an interesting alternative response to seed quality challenges would be to explore ways of investing in strengthening relationships between seed sellers and buyers, including personal and socially valued relationships, to tap the power of reputation that could reduce fraud and yield additional benefits.

5.2 **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 in a timely manner of desired, good-performing varieties, cause economic and productivity losses and discourage reliance on that particular seed channel. These factors are discussed here in relation to the regulatory context, collaboration between seed system actors, and diverse models for dissemination.

5.2.1 *Regulatory Context*

The regulatory context is understood here to encompass socio-cultural as well as legal norms, both of which influence the availability of seed to farmers. 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 rainfed and submerged production systems, are strongly influenced by such norms in Mali (Coulibaly *et al.*, 2014). Approaches that consider such norms are showing benefits in contributing to availability of new varieties in Mali (see also Siart, 2008; Deu *et al.*, 2014; Smale *et al.*, 2016). Although in Kenya the social norms relating to seed have weakened, seed proximity and timeliness of seed availability, coupled with issues of trust, 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.

The official registration and release procedure controls which varieties can or cannot be made available in commercial seed systems. Currently, local cultivars ('landraces') of maize and sorghum are basically not released in Kenya or Mali, which blocks availability of these varieties through commercial channels and exposes long-standing farmer practices relating to seed exchange to criminal charges. Furthermore, the commercial availability of new varieties is slowed down through the official release procedure. However, in a situation where commercial seed systems cannot provide farmers with the quality and diversity of seed that is actually required (see Section 5.1), these restrictions appear counterproductive to sustainable seed system development. Exploring alternative legal seed regulation and pathways to speed availability of new varieties and to ensure commercial availability of local varieties was thus an overall primary priority identified in the workshop with seed system actors in Kenya, and was also hotly debated in Mali.

Actors in both countries suggested that seed certification services could be decentralized, or that seed commercialization based on standards such as QDS could reduce costs and delays caused by the certification process. Such a system appears to match farmers' experiences and expectations for traditional staple cereals, with responsibility for seed quality borne by those who produce and provide seed. Furthermore, it could also encourage local initiatives in the breeding and seed sector; for example, 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).

To summarize, regulatory systems that provide space for a diversity of approaches for varietal development, release and seed production are expected to have a better chance of meeting the enormously diverse needs of smallholder cereal farmers in countries like Kenya or Mali, with a wide range of agro-ecological conditions and production systems, compared with systems that focus on a narrow range of actors and variety types.

5.2.2 *Collaboration Between Seed System Actors to Improve Availability of new Varieties*

Availability of seed of new varieties to farmers in both Kenya and Mali is highly or entirely dependent on collaboration between public and private sector actors. 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).

Constraints on variety development due to limited funding levels and dependence on short-term project grants 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.

A wide array of options exists, from public sector breeders 'nurturing' emerging seed companies, to farmers and value-chain actors raising their own funds for demand-driven public research; such options are described in more detail by Christinck *et al.* (2017a). Particularly in view of rapidly changing agro-ecological production conditions, climate change, and socio-economic transformations, such innovative models of collaboration could enhance the dynamics and innovation capacity of seed systems, making more and better varieties available to farmers and increasing the level of varietal diversity. Furthermore, the potential of improved collaboration between actors for reducing transaction costs could be a matter of shared interest.

5.2.3 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, to be effective, seed delivery channels need to respond to this challenge.

Different models of seed dissemination that are common in Kenya and Mali were identified by Christinck *et al.* (2017a) and compared based on the seed system functions to which they contribute, or where each is adding value to the system. The first model is the 'farmer seed-producer cooperative' that is engaged across most functions, from collaboration with breeders, through production, to marketing and selling seed. The second type of enterprises is 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 that are typically found in Kenya, 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.

There are two main reasons why farmer-managed seed cooperatives in Mali have comparative advantages for improving availability of improved seed in rural areas (Smale *et al.*, 2016): one factor is simply their location in rural areas, where they are usually engaged in agricultural development for their village, community, or a larger area (Wennink *et al.*, 2012), and proximity to clients with minimal cost. Another factor is their active collaboration with 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 evaluation trials and joint collection of feedback from other farmers.

Private seed companies, in contrast, 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, which usually occurs through multi-level distribution networks. Furthermore, their access to farmer feedback depends considerably on the company's capacity to interact with their clients, which implies additional costs. Hence, such distribution networks are most effective for large-scale distribution of a few, well-known varieties to areas where they are widely used, and is less effective for situations where demand is limited and highly diverse.

5.3 Seed Access

Access to seed is the final determinant of whether improved seed is sown, and can thus provide benefits to its users. It 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 with the person providing the seed. Seed access is discussed in the following sections, based on social

and monetary dimensions of seed access. Furthermore, free seed distribution and other options to enhance seed access are briefly presented.

5.3.1 *'Social Seed Price'*

The conditions under which seed can be acquired in a range of situations can be a determinant of access. In Mali, where cultural norms regarding seed of traditional cereal crops are very strong, a person who is asked to provide seed gains status and is culturally obliged to give the seed, mostly for free or on an exchange basis, while for the person in need, the transaction may involve a loss of status. The 'seed-to-grain price ratio' in this system is never more than 1:1. 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. At the same time, the 'social price' of seed is high, leading to a situation where it is a priority for 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 and existing options for seed access into careful consideration.

The many, and the 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; paying cash to the cooperative and not to an individual; or the cooperative offering seed on a barter basis, but reflecting the monetary value.

In Kenya, where maize is an introduced crop, and sorghum is a largely marginalized crop, such cultural norms regarding seed seemed to be 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 percent, are widespread and applied regularly, especially by smallholder farmers. This local knowledge is practiced for two reasons: (a) security in case their favourite maize hybrid is not available or the family is unable to mobilize sufficient cash to buy seed; and (b) to ensure availability of seed of local varieties that cannot be accessed otherwise.

5.3.2 *Seed Prices 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, are quite similar in Kenya and Mali. Although our estimates are rough approximations due to limited information and 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 USD, reveals that seed prices in Kenya can be up to twice as high as in Mali. Thus, the relatively high price of seed in Kenya could explain why farmers there tend to consider the seed price when choosing a hybrid to purchase (Smale and Olwande, 2014). In Mali, however, seed price was seldom mentioned as limiting access to seed, given the fact that more possibilities exist to get seed in small packages, or on a credit or exchange basis.

Important differences also exist with regard to 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 one-third of the retail seed price. Thus, approximately two-thirds of the seed purchase price paid by farmers covered the costs to 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 percent of the price farmers paid when purchasing seed from the cooperatives; thus, the costs for certification, conditioning, marketing and distribution were much lower in this case (one-fifth of the retail price). Hence, 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.

5.3.3 *The Cost of Free Seed*

Direct free seed distribution was a hot topic for discussion not only during the individual interviews, but also during the workshops in both countries. The farmers who were 'beneficiaries' of seed distributions often expressed discontent due to various shortcomings: seed often arrived late; had a high chance to be of poor germination capacity (Kenya); or arrived in poorly labelled seed packages (Mali). Furthermore, there were cases of serious adaptation problems as the cultivars were not suitable for local growing practices, leading to crop failure; and the seed did not always reach the targeted farmers.

Agrodealers, as well as other businesses involved in local seed dissemination, were unhappy as they lost business opportunities due to the free seed distributions. At the same time, some seed companies rather favoured such contracts, as they allowed them to deliver large consignments without having the costs for local dissemination. However, they also realized that the free distribution did not contribute to the development of sustainable seed dissemination networks.

5.3.4 *Financial Management Tools to Facilitate Seed Access*

Limited cash availability or cash-flow constraints were mentioned as influencing decision-making and 'room for manoeuvre' of various seed system actors, including farmers, seed producers and seed sellers. Seed producers reported problems due to the long time interval between start of the production cycle and incoming payments, which is longer than a normal agricultural production cycle. Seed sellers could not always meet demands for specific varieties or tended to limit the range of varieties offered to certain popular hybrids. In the case of farmers, limited cash availability was reported by some farmers as restricting access to certified seed of improved varieties, 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.

A general distinction can be made between cash availability for long-term investments, e.g. for seed processing facilities or other technical equipment, and seasonal credits that allow normal operations and are usually paid back after sale of the product (ISSD Africa, 2017). A range of financial tools are available for each of these areas of demand, including own savings, group savings, microfinance, bank loans (sometimes in association with guarantee funds), or grants (ISSD Africa, 2017).

One particularly interesting option for seasonal cash requirements is value-chain financing, where the buyer of the final product, be it seed or grain, provides credit to those who produce it, sometimes even on an in-kind basis. The main advantage of such 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.

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-programmes for input purchase. One innovative model is based on using a cell phone layaway plan, with which farmers purchase a selected package of inputs³¹.

³¹ More information on www.myagro.org.

5.3.5 *Cross-cutting Issues*

Gender and communication were found to be issues that cut across the three factors of seed quality, availability, and access. For example, gender issues were identified regarding varietal attributes and diversity, as well as regarding dissemination pathways and financial management tools.

Developing gender perspectives in agricultural research 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.*, 2017b).

Hence, a more gender-inclusive approach to seed system development should not just look at women as a 'disadvantaged' customer group, but rather consider needs and potential contributions of women and men systematically with regard to all seed system functions.

Furthermore, 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. One major communication challenge is how to enable millions of smallholder farmers to gain access to varietal information of pertinence to them.

Besides classical approaches, such as field days or demonstration plots, some interesting new approaches to provide information to farmers on a large scale were identified, e.g. based on online search portals or mobile applications. Yet they are all designed and implemented in a more top-down manner, while there appears to be some emerging efforts at gathering and sharing information on varietal performance at the farmer level. Hence, such approaches could build on the 'traditional' method of farmer-to-farmer exchange networks, while new communication technologies using applications for use with mobile devices, farmer-to-farmer video messaging, etc. could be used to accelerate and scale up knowledge sharing.

In general, collaborative learning of actors with diverse and complementary expertise is powerful for creating collaborative advantages and facilitating innovation, and has also proven to be highly relevant for seed system development. 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 to 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 programmes collaborating with numerous cooperatives, associations or unions of cooperatives.

6 Conclusions and Entry Points for Sustainable Seed System Development

The **need for stronger actor orientation** to enhance seed system functioning at all levels was 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. Advantages of this approach are that it is feasible with simple explicit efforts to focus on all actor types and their interrelations, and it can serve as a springboard to concrete actions with potential for sustainably enhancing seed system functioning.

Sustainable seed system development requires that **farmers' needs and capacities receive central 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 continuing 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. Practical examples include enabling public access to what national varietal performance data exists, farmer experiential learning through variety tests, and gathering varietal performance data from demonstration plots to build 'data banks' on varietal performance and profitability for diverse farmer and production conditions. Enhancing how information is shared, including training and use of multimedia and new ICT tools such as applications for mobile phones; video; or radio, and efforts to provide user-differentiated information, particularly for smallholder farmers, including women and men, all represent major opportunities.

Decentralized seed production and marketing based on farmer-groups and cooperatives can provide nuclei 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 programmes in variety testing and development. Study of why these farmer enterprises currently play a strong role in Mali and are rare in Kenya could be informative.

Plant breeding, as the source of value creation, needs to be regarded as an integral component of functioning seed systems and requires appropriate funding for sustainable seed system development. 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. For example, increased attention to desired grain traits for on-farm use and processing could substantial help raise varietal adoption by small-scale farmers and women for whom household food security is an important priority. Enhanced linkage of breeders with different seed system actors will improve information flow and result in variety portfolios that better respond to actors' priorities for production and use.

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 by Christinck *et al.* (2017a: Annex). Ideally, the actors directly concerned would be involved in defining these actions in detail, thus enabling ownership, completeness, and depth.

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