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Gender and Roots Tubers and Bananas Seed Systems: A Literature Review

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Acronyms

CIP	International Potato Center
CMD	Cassava mosaic virus disease
FAO	Food and Agriculture Organization of the United Nations
FGs	Farmers' groups
GLCI	Great Lakes Cassava Initiative
HH	Household(s)
NGOs	Nongovernmental organizations
OFSP	Orange-fleshed sweetpotato
PPB	Participatory plant breeding
PVS	Participatory varietal selection
QDS	Quality declared seed
RMTs	Rapid multiplication techniques
RTB	Roots, tubers, and bananas
SSA	Sub-Saharan Africa

Abstract

Using literature review this paper seeks to discuss gender integration into design and understanding of seed system interventions in roots, tubers, and bananas (RTB) crops. It focuses mainly on offering a critique of the multi-stakeholder framework for intervening in RTB seed systems, and offering suggestions on how to integrate gender into the framework. The paper emphasizes the importance of understanding how social structures and informal rules such as gender and cultural norms determine participation in, and benefit from, seed systems. In addition, existing social systems and cultural norms may govern or influence how the different stakeholders—including scientists, extension workers, and practitioners among nongovernmental organizations (NGOs)—act and relate with male and female farmers. Men and women may face different constraints and opportunities to participate meaningfully in seed systems, and these different constraints need to be understood in order to define seed systems interventions that can meet their needs. They may also have different perceptions about quality. As a result, seed system interventions also need to carefully examine how the different stakeholders in the seed system relate with farmers and whether gender biases filter into interactions disadvantaging women over men.

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Gender and Roots, Tubers, and Bananas Seed Systems: A literature review

1. Introduction

Using literature review this paper seeks to discuss gender integration into the design and understanding of roots, tubers, and bananas (RTB) seed system interventions. Almost 200 million poor farmers are estimated to depend on RTB crops for food security and income. And although it is not known how many of these farmers are women, it is generally stated that women and children are among the poorest globally (FAO n.d.). It is therefore reasonable to assume that women farmers dominate among those who depend on RTB crops. For example, Kaguongo et al. (2012) note that the sweetpotato “is traditionally regarded as a poor man’s crop as it is typically grown and consumed by resource poor households, and mainly by women, and it gives satisfactory yields under adverse climatic and soil conditions, as well as under low or non-use of external inputs.” Discussing global trends, Scott and Maldonado (1999) state that 98% of sweetpotato produced globally is harvested and utilized in developing countries, and that East and Southern Africa noted an increase in sweetpotato consumption per capita with falling incomes. Furthermore, roots and tubers not only provide food for households (HH), but are a potential source of income for farmers (Scott et al. 2000).

As noted by CGIAR’s RTB (RTB 2013a), however, the relationship between RTB crops and gender is complex. RTB gives an example of the Kagera region in Tanzania, where men are in charge of producing bananas and women of cassava and sweetpotato. On the other hand, in Nigeria’s Nasarawa and Kwara states, David (2015) notes that because of men’s culturally and religiously sanctioned responsibility of providing food, men dominated the cultivation of local staples including cassava, sweetpotato, and yam. The diversity of cultural and institutional arrangements regarding the cultivation of root crops serves to show that these crops are important for both men and women and play a critical role in the food security of vulnerable HH.

Although no systematic attempt has been made to measure women’s contribution in economic terms, the role that women play in agricultural production, both as unpaid family farm workers and as paid laborers in the agricultural sector, can hardly be overestimated (Spielloch 2007). It has been estimated that in developing countries, rural women produce 60–80% of the food and are also the main producers of the world’s staple crops, which provide up to 90% of the rural poor’s intake (FAO 2006). The World Bank acknowledges the central role played by women in agricultural production by stating that since “women are the main food producers in farm households, and ... their seed security — in other words, their access to reliable supplies of good seed — is of the highest priority” (WB, FAO, and IFAD 2009, cited in Galiè 2013). In spite of this heavy involvement of women in food production, and the

acknowledgment by different international and national development bodies about this, it has been noted that women are least able to influence the governance of seed systems and natural resources (Galiè *ibid.*).

Seed is directly linked to the issue of food security and poverty reduction. FAO (2003) stated that food security, at the individual, HH, national, regional, and global levels, is achieved when all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for a healthy and active life. From this perspective, access to good quality seed could help to reduce poverty. Ravinder et al. (2007) regards seed as “a powerful agent of change,” with the potential of making a difference in the lives of the poor and marginalized as access to good quality seed could increase productivity. In addition, having access to good quality seed could ensure higher productivity in the sense that quality seed is regarded as a prerequisite to make other inputs, such as fertilizers, cost-effective (see also Walelign 2008). Thus if farmers use fertilizers with poor quality seed, they may not be able to reap the benefits of the fertilizer inputs. Venkatesan (1994) regards seed as “the most important and least expensive of the cash inputs.” While many other areas are also important for agricultural development (e.g., markets, credit supply, support institutions, and policies), access to appropriate seed is clearly the first step (McGuire 2005, cited in Walelign 2008). Recognizing the importance of seed, the People’s Summit on Climate Change, held in Cochabamba, Bolivia, in April 2010, ratified the concept of food sovereignty (which focuses on people’s right to food) to also include the people’s right to control their own seeds, lands, and water.

Given the centrality of seed in agricultural systems, it then follows that if women are to benefit from agriculture they should also be involved in decisions about seed. There is evidence that women will benefit if they are involved in empowering ways within seed systems and not only when they are involved just as providers of labor. For example, women involved in a participatory plant breeding (PPB) exercise for barley and rice in Syria stated they had benefited since PPB barley seed and varieties sold for a better price and contributed to family economy (Galiè 2013). As a result of the gender division of agricultural labor in Latin America in the Peruvian Andes, “gender relations are central to seed management” (Zimmerer 2003). Although both men and women are involved in seeding of fields, women are responsible for storeroom management of tubers. In a study in the Andes, Tapia and Torre (2008) note how women were central to seed system and maintenance of biodiversity for root crops, yet their knowledge was often ignored in seed system and biodiversity interventions. In Africa, Gibson et al. (2009) observe a similar pattern in which although sweetpotato production is dominated by women, there is no specific study on gender in sweetpotato seed systems.

Furthermore, Sperling and McGuire (2012) suggest that since seed security programs are normally implemented “among some of the more vulnerable and least resilient of populations,” we should understand whether the strategies “guiding seed security vision and operations [are] sufficiently sharp to serve the needs of those already compromised.” For instance, they identify a gap in that seed programs may focus on production of quality seed but do not address whether farmers are willing and

even able to pay for it. There is also evidence that seed system programs and interventions may fail to acknowledge the importance of gender. The Great Lakes Cassava Initiative (GLCI), developed to help farmers in six countries in the Great Lakes Region in East and Central Africa mitigate the impact of cassava brown streak disease and cassava mosaic disease (CMD), managed to reach 2,962 farmers' groups (FGs) with a membership of close to 68% women (CRS 2012). GLCI aggressively tracked female participation in training as seed producers, as seed recipients, and as participants in field demonstrations, yet the program report noted that gender had been a low priority at the beginning of the program. As a result, studies that could have helped address gender and diversity issues in GLCI's workplace, along with implementation to make any meaningful changes to the program to ensure that gender was integrated, were not conducted at the beginning of the program (ibid.).

In the following section we define what seed systems are in order to lay the groundwork for understanding them from a gender perspective. In the third section we introduce the multi-stakeholder framework for intervening in RTB seed systems advocated by Sperling, Ortiz, and Thiele (2013), to examine its efficacy in addressing social and gender issues related to seed systems. In the discussion section we examine some of the limitations of using this framework and how they can be addressed. We also suggest possible questions that could be used in research that seeks to understand seed systems from a gender perspective.

1.1 WHAT ARE SEED SYSTEMS?

The important role of seed systems can hardly be overestimated. For example, Galiè (2013) regards seed as “a key to food security because seed is the first link in the food value chain.” She goes on to suggest that in order to understand seed systems, we need to understand the formal as well as informal rules (including customs and norms) that influence how different people will act and also whether they will benefit from the system. Thus a simpler definition of seed systems refers to the rules (both formal and informal) that govern access to and use of seed. Reddy et al. (2007) defines the seed system “as the sum total of the physical, organizational and institutional components, their actions and interactions that determine seed supply and use, in quantitative and qualitative terms.” Seed systems are governed by both formal and informal rules that impact on the level of influence and participation for both men and women and their ability to benefit from the system.

Gibson, Namanda, and Sindi (2011) neatly summarize the role of seed systems by stating that they “need to provide farmers with planting material (i) in sufficient quantities (ii) at the right time (iii) of an appropriate physiological state, vigor and health, (iv) of superior genotypes appropriate to the farmer's purposes, and (v) at an affordable price.” When successful, seed systems (whether formal, informal, or integrated) will ensure seed security for farmers. FAO (n.d.) define seed security as “timely availability of improved variety and ecotype of staple crop kinds to farmers especially after disaster, and its efficient distribution at the right place and at affordable price.” McElhinny et al. (2007) state that seed insecurity may refer to a “high likelihood that they [farmers] do not produce sufficient seed in one year for the following year.” Seed insecurity is a big threat to productivity. Seed security can be both at the HH and

community levels. As noted by Scowcroft and Scowcroft (1999), HH security “depends on – quality of seed and cultivar diversity; quantity of seed of the right type and planting time and adequate storage to protect against pest and looting”; whereas “Community security depends on: relatives, neighbors and relief agencies, local markets and seed distribution channels; and established village seed banks.”

Seed systems in developing countries may need to integrate both formal and informal systems. Below we discuss the two separately.

1.1.1 Formal seed systems

Formal systems include public and private companies. They strive to meet national and international standards of seed breeding and are governed by national legislation and policies to ensure the availability of quality seed at the right time. “The formal SS [seed system] usually controls seed multiplication to assure sufficient quantities of breeder, foundation and certified seed of guaranteed quality” (Biemond et al. 2012). Although the formal sector dominates the seed systems in developed countries, in developing countries “90–95% of the world’s small holder farmers still obtain seed from informal sources, largely from other farmers” (Reddy et al. 2007).

There has also been less focus on tuber crops, legumes, and horticultural crops among the formal seed systems of sub-Saharan Africa (SSA) (Biemond et al. 2012). Formal seed systems are recognized as having failed to provide enough seed for potato and sweetpotato. For instance, in Peru, Bolivia, and Ecuador formal seed systems account for only 5% of seed production (Zimmerer 2003). Kapingai et al. (2005) estimate that in SSA for all crops, 5–10% of farmers purchase seed produced by formal organizations. “As a market oriented business, the private sector does not tend to offer a wide range of varieties for crops, it does not provide seed for minor crops due to limited demand, and it is not able to distribute small quantities of seed to remote areas” (Almekinders and Louwaars 2002, cited in Biemond et al. 2012). The vegetatively propagated crops have unique problems. For example, “cassava and sweet potato are propagated through use of vegetative parts, which entails certain problems, such as low multiplication ratio, bulkiness, short shelf life, and difficult dry season maintenance, in the case of sweet potato” (Moyo et al. n.d.). Although in general in many SSA countries seed systems are not well developed, the only commercial seed businesses in SSA are for hybrid maize and vegetable seed. Commercial seed companies do not invest in legume seed nor in cereal seed that is not maize.

1.1.2 Informal seed systems

Biemond et al. (2012) stated that in developing countries, 60–100% of farmers depend fully on informal seed systems to access planting material. Smallholder farmers may need smaller quantities of seed or planting material, and therefore their needs can be met in the informal system. “Informal traditional seed systems/farmer managed systems operate at the community level through exchange mechanisms. They involve limited quantities per transaction” (Reddy et al. 2007). Although informal seed systems can be local in character, farmers may also get seed from networks existing outside their immediate community (Walelign 2008). Within the informal system, sourcing options for seed can include buying

from local informal markets and other farmers, families, or neighbors, or through own-saved seed. Within the informal seed system, networks play a very important role (Badstue et al. 2007), and “seed transactions occur within a set of specific social relations” (Badstue et al. 2002). But a potato seed system study conducted in Malawi by Mudege et al. (2015) shows that even where selling and buying seed depended on relations of trust, profit considerations as well as concepts of fair value and fair exchange also dominated. When farmers do not have money to purchase seed, the informal sector, through its reliance on social networks, provides avenues for access to seed. For instance, in a potato seed system’s piece work, borrowing from friends and gleaning/scavenging are ways that farmers who did not have cash to purchase potato seed could access seed (Mudege unpublished).

Informal systems are also sometimes referred to as “traditional systems” because they may rely on indigenous knowledge of plants and crops and local/indigenous systems of seed selection, seed management, and seed diffusion (Reddy et al. 2007). Although informal seed systems play an important role in preserving biodiversity (Tapia and Torre 1998), they also expose local seed systems to risk, thereby increasing seed insecurity. In the informal sector, “seed may be manually cleaned but is otherwise generally left untreated, which exposes the resulting crop to the risk of seed-borne pests” (Reddy et al. 2007). This is a particularly critical point for vegetatively propagated crops, which have a high risk of disseminating diseases through vegetative planting materials (Ortiz et al. 2012). In addition, some diseases are symptomless, meaning that farmers may not be able to select against infection, and further increasing the risk of disease spread (Gibson et al. 1999).

1.1.3 *Integrated*

As a result of perceived strengths and weaknesses of the formal and informal seed systems, integrated seed systems that combine aspects of the formal and informal systems are sometimes regarded as better suited to address the seed needs of many small holder farmers. According to Nagarajan and Smale (2005), “A well-functioning seed system is defined as one that uses the appropriate combination of formal and informal supply channels, market and non-market transactions to stimulate and meet efficiently the evolving demand of farmers for quality seeds.” Almekinders et al. (2008) note that farmer seed systems (referred to here as “informal”) and the formal seed sector are poorly connected and basically operate as two parallel systems with “relatively little interaction.” The authors advocate, however, for an integrated system whereby the formal system can interact with the informal one, strengthening it by supplying new genetic material adapted to a variety of local conditions (e.g., disease and climate). Moreover, farmer seed systems can be used to select varieties and desirable traits through participatory crop improvement activities. Thus the integrated system will involve research and development providing quality planting material to farmers. In the integration of formal and informal systems, the primary multiplication site managed by researchers provides “disease-free (“clean”) planting material” and secondary and tertiary multiplication sites that are managed by trained farmers are located closer to the farmers (Abidin 2012).

Locating multiplication sites closer to farmers, especially in the case of vegetatively propagated crops, is critical since vines are perishable and often bulky to transport. Venkatesan (1994) states that “The decentralized farmer-based model is particularly suitable for the propagation of the planting material of tuber crops.” Decentralized farmer-based models for seed dissemination are used extensively in RTB systems. For instance, GLCI developed and worked through a network of more than 2,000 FGs to produce and disseminate CMD-resistant varieties near more than 1.2 million farmers in six countries.

In addition, integrated seed systems may also involve the formal system (researchers) building the capacity of stakeholders such as farmers on different agronomic practices related to crop production and seed management. For example, the Crop Crisis Control project was initiated to help mitigate CMD and banana *Xanthomonas* wilt in East and Central Africa. The project had a strong farmer capacity-strengthening component for national agricultural research systems to help build regional institutions to respond to the problem of both these diseases, as well as a farmer training component (Karamura and Johnson 2010). At the end of the project, it was estimated that in target benchmark sites a combination of farmer training and institutional strengthening saw an estimated 51,400 farmers who had been trained on disease symptom and control measures, tripling their yield and reduction of disease outbreak reporting by 20–40% (ibid.).

Tiwari et al. (2010) noted that farmers residing in remote areas and not integrated into markets may not be able to adopt new seed varieties, even when they are aware that these varieties exist. The authors advocate for decentralization of seed production under so-called “community-based seed production” systems (i.e., decentralized farmer models), which have been credited with improving access to seed and new varieties in remote communities. Although Tiwari et al. (ibid.) were focusing on cereal systems whereby seed is much easier to transport and store, the implication for RTB crops cannot be underestimated: RTB crops have higher planting density (need for much more volume for planting) and their planting material dies within weeks of leaving the field.

1.1.4 Gender and Seed Systems

The previous section on seed systems also highlights that seed systems can be understood at multiple levels—at the international policy level, national/local level, and HH level as it relates to decision-making. Gender permeates at all these levels. Many different actors are involved in the seed system, and their needs and interests should be recognized and addressed. Seed systems not only involve all actors participating in “breeding, seed production, quality control and dissemination” (Biomonda et al. 2012), but also include activities such as marketing and use of seed by farmers (Venkatesan 1994). Since both male and female farmers who may have similar or different interests are involved in seed systems, any attempts to intervene in or improve seed systems should take their differential needs and interests into account in the development of seed programs. For instance, Venkatesan (ibid.) notes that “without an effective extension system responsive to farmers’ needs, it would be difficult to develop a seed system, particularly in formal seed systems, where extension’s role is critical.” Extension provides a way to bridge the gap between science (global and local research) and practice (local farmer level); it is

assumed to lead to better farmer decision-making, improved agricultural performance, and better outcomes (Anderson and Feder 2004).

In spite of the realization of the need for knowledge-intensive agricultural systems, many studies in Africa have consistently demonstrated the lack of access to information for both men and women farmers (Katungi et al. 2008), with women farmers even worse off due to the social and cultural restrictions they face when they try to access information and training. According to Boodhna (2011), women receive 10% of extension services required to boost food production. Mudege and Verhart (2012) note that “agriculture extension agents are more likely to visit male farmers in male-headed households than female farmers in female-headed households and when they visit they invariably focus on commercial agricultural crops rather than subsistence crops that women usually focus on.” Therefore, to be effective, seed systems also need to address gender biases that exist within the different components of the system.

When effective, a seed system will “make good quality seed available to farmers at the right time at low cost” (Reddy et al. 2007). This points to the need to involve male and female farmers alike at all stages of the seed system to ensure that their needs are met. For instance, Abidin (2004) suggests that involving farmers in the early stages of selection programs is useful to assist with the problem of fitting crops to a multitude of target environments and user preferences. For example, in a research program conducted by the International Center for Tropical Agriculture on a participatory evaluation of the genetic material of beans, the bean varieties “selected by the female farmers had production increases of up to 38 percent over breeder-selected varieties” (Quisumbing and Pandolfelli 2010). In spite of accumulation of evidence in different cropping systems, there is a general tendency to assume that seed governance debates are gender neutral (UN 2000, cited in Galiè 2013).

Thus, to ensure seed security for both men and women farmers, Minot et al. (2007) state that seed programs should take into account the function and operation of local seed channels as well as the involvement of women seed users and women traders. LinkS was a large-scale study funded by the Food and Agriculture Organization of the United Nations (FAO) and launched in 1998 in six countries in Southern Africa. The project “sought to explore the linkages among the crucial issues of local knowledge systems, gender roles and relationships, food provision, and the conservation and management of agrobiodiversity” (ICRISAT 2004), and revealed a clear difference between men and women’s responsibilities with respect to crops and seeds (see FAO n.d.). “Women are involved in producing subsistence food crops such as beans, peas, potatoes, cassava, finger millet, and vegetables, while men are more concerned with producing crops for cash” (ibid.). In addition, the LinkS studies demonstrated a striking relationship between gender and seed security. Female-headed HH were, on average, poorer than those headed by males and were therefore likely to be less seed-secure in terms of their ability to purchase and access seed from external sources (ibid.). Furthermore, in areas affected by male labor migration, women are a “key source of knowledge on seed, yet, women’s local knowledge – as well as their access to new information – has often been marginalized by formal sector interventions” (ICRISAT 2004). Thus

addressing the needs of women and men farmers in terms of skills related to seed management could help to address the problem of food shortage (Gurung and Gurung 2002).

According to Brody (2009, cited in Galiè 2013), bringing a gender dimension to seed governance implies, involving both women and the most marginal groups in decision-making processes and ensuring that governance regimes take into account the different responsibilities, priorities, and needs of men and women. According to Alemu et al. (1998, cited in Waleign 2008), “human capital variables such as literacy; farm size; information sources such as agricultural extension or the research station; and distance from seed sources” can influence farmers’ awareness of and adoption of new varieties. Farmers with more land had a higher probability of adoption, probably because they are wealthier and have more land to experiment with improved wheat varieties. Extension visits also resulted in a higher probability of adoption by raising farmers’ awareness (ibid.). All these factors are also gendered. For instance, women may not always have access to land or to credit, which may affect their ability to participate in the agricultural sector, including in seed systems. Furthermore, as noted earlier in this paper, extension workers may target HH heads (who are more likely to be men), leaving women behind. “Men and women differ in their access to, and control over inputs, productive resources and services, which limits the opportunities of men and women to participate productively in agricultural development” (Kingiri 2010). Lack of access to resources for women and other poor farmers may provide unique constraints to their effective participation in seed systems.

With this in mind, women’s ability to access and use seed must be enhanced (WB, FAO, and IFAD 2009). This is possible if seed systems design recognizes the role of women in agriculture and food security and come up with systems and solutions that meet their needs. And although there has been a movement toward more integration of seed systems, there is not much research done on the gender implications of such models. For example, the Papa Andina experience in Ecuador, Bolivia, and Peru, which aimed at improving farmers’ livelihoods through innovation in market chains, showed that while becoming part of the CONPAPA seed producers’ groups was empowering for women, it may also have overburdened them. Men were found to still manage the most important events and are in charge of making the most important decisions about seed and potato production in CONPAPA seed producer groups. For example, in Ecuador 62% of participants in training were men, who participated more in task groups and field visits than women. Men made decisions on sale of products, cash management, and input use; they generally decided on all activities related to agricultural production in CONPAPA. More than 70% of those who participated in decisions related to area to be planted, variety to be planted, planting date, pest control, cash management, and income distribution were men, whereas women dominated (at 67%) in decisions related to harvesting in the CONPAPA groups (Conlago et al. 2011). How gender norms may interfere with women’s ability to participate in seed systems has only begun to be studied—for instance, in relation to participatory varietal selection (PVS). For example, Galiè (2013) noted how gender biases by extension officers affected women’s ability to participate and to benefit from PPB

exercises. Gender division of labor, norms governing gender relations, and women’s ability to access and own resources can also affect their ability to participate and benefit from seed systems.

2. Multi-stakeholder framework for intervening in RTB seed systems

To understand seed needs, and to respond to seed needs appropriately, the value of a seed framework that can help diagnose and access the seed related issues and problems cannot be overestimated. In 2013, RTB started to develop a seed systems framework for intervening in RTB crops in order to help design and develop seed systems interventions and to help seed systems stakeholders to “think strategically, diagnose, and plan practically” (Sperling et al. 2013). This seed framework seeks to address many components of the seed systems. For example, it not only deals with seed availability (quantity and proximity), but also goes further to address issues related to delivery models (how seed will be delivered to farmers), knowledge that farmers have to utilize the seed, and a cost-benefit analysis for both seed producers and farmers (Sperling and McGuire 2012).

The framework has many ingredients of an integrated seed systems framework. For instance, it recognizes the that there are multiple stakeholders responsible for different aspects of the seed system, both from formal research institutions and policymakers right to the seed producers (who include farmers, traders, and private sector) and seed users (Table 1). The framework provides a way to understand how the different actors in the seed system are linked yet have different perspectives related to seed access, availability, and quality.

Table 1. Multi-stakeholder framework for intervening in RTB seed systems (RTB 2013b)

Group of Stakeholders	Availability	Access			(Knowledge on) seed quality			Policies & Regulations		Sustainability, Resistance	Equity & Gender	Change (use the matrix twice)
		Source, delivery channels	Knowledge, capacity awareness	Affordability	Health	Physiological	Purity	Formal	Informal			
Policy makers												
PGR researchers												
Seed producers and providers (including traders and farmers)												
Seed users												

Having a conceptual framework may be useful to identify, for example, issues particular to a stakeholder as relating to access to clean planting material. The problem of seed access and its solution means something different to a smallholder farmer than to a seed producer or breeder. This is not to suggest there is a single problem and solution but, rather, a plurality of issues and responses that need to be understood so as to achieve more integrated seed system analysis and solutions. Seed accessibility

within the framework comprises three distinct but interconnected pillars: seed sources or delivery channels, farmer knowledge of seed, and the affordability/opportunity cost of farmers to access seed.

Further discussion on the conceptual framework (RTB 2013b) led to the identification of three overarching themes that were used as focal areas for documenting and analyzing a series of 13 RTB case studies (Andrade-Piedra et al., 2016). Each of these research themes—farmer demand for seed, seed regulation and policies, and tools and techniques for seed multiplication—is discussed below.

Farmer demand for seed is concerned with understanding farmer demand, the costs–benefits of seed, and the value of specialized seed producers. Preliminary analysis of the 12 case studies associated with validating and refining the conceptual framework suggested little evidence of farmer-demand assessment, indicating that most interventions are based on assumptions about farmer demand. This can imply that the case study interventions were supply driven and that there is a lack of understanding of farmer demand for seed.

The **seed regulation and policy** theme is focused on understanding how standards can enable farmers and seed producers to improve the quality of seed used. Preliminary analysis of the 12 case studies associated with validating and refining the conceptual framework shows a limited use of seed regulations for RTB, and levels of control and enforcement of RTB standards are largely unanswered. There is also a need to understand how seed regulations can be optimally used to mitigate declining seed quality over successive generations (degeneration).

The research theme of **tools and techniques for seed multiplication** is oriented toward identifying the appropriate application of different seed propagation technologies for different contexts and stakeholders. Preliminary analysis of the 12 case studies associated with validating and refining the conceptual framework demonstrate that rapid multiplication techniques (RMTs) are relatively knowledge, capital, and labor intensive, raising questions about who uses and benefits from them.

Each of these research themes has gender-specific considerations; but in the analysis to date, there has been an orientation to conduct gender analysis specific to these overarching themes. This may present an opportunity moving forward.

Below we discuss some of the key components of this conceptual framework for intervening in RTB seed systems from a gender perspective.

2.1 AVAILABILITY

Seed availability is affected by “shortage of healthy planting material, pests and diseases and unreliable markets during surplus production” as well as prolonged droughts and dry spells that can kill any surviving vines (Kapinga et al. 2005), resulting in lack of availability of planting material at the beginning of the rainy season. Farmers also lack the knowledge, skills, and resources to maintain clean planting material between seasons especially if they experience long dry spells (NRI 2001). Men and women may

be affected differently by availability (or lack thereof) of planting material. For example, the gender division of labor may mean that saving seeds is regarded as a woman's function (Gurung and Gurung 2002). LinKS studies in Southern Africa found that women were regarded as being responsible for seed selection and management of traditional food crops and other noncash crops. If women are largely responsible for managing seed, it means that the seed system also needs to meet their needs and demands. When a seed system is not effective, lack of seed becomes a major constraint to crop production and improvement. Where a large majority of women and poor people depend on the crop, they are likely to be disadvantaged when the system is not optimally performing. Seed solutions to addressing seed availability issues need to be built closely with the specific farmer-demographic dependent on the crop. On the other hand, "gender-sensitive seed governance is believed to enhance women's seed sovereignty, that is their ability to access and control seed in ways commensurate with their roles as food providers, producers and preservers of food cultures" (WB, FAO, and IFAD 2009).

2.2 ACCESSIBILITY

Accessibility refers to the ability of men and women farmers to access available seed and use it correctly. As outlined in the framework, accessibility will be split into three aspects: delivery channel features, affordability and profitability, and information (related to awareness and demand creation).

2.2.1 *Delivery channel*

Group approaches to dissemination and delivery of new planting material are commonly used in RTB crops in SSA. Group approaches can integrate a PVS component (in which farmers are involved in testing and evaluating planting material) or not. Where PVS is not an integral part of the design, FGs can be trained, then freely given planting material to plant and disseminate to other farmers through sales and gifts. For instance, GLCI worked with close to 2,900 FGs in six countries to disseminate clean, CMD-resistant cassava planting material. In Malawi, the Irish Aid-funded potato project is also using the group system to disseminate seed (Mudege et al. 2015). In Malawi for instance, because extension services are often understaffed, the government promotes pluralistic agricultural extension services involving NGOs and the private sector as well as the promotion of FGs and lead farmers. Farmers who are organized in groups are more likely to gain access to government and extension resources and information, than are those who are not in groups. (See the case on adoption in Kalima dry bean in Malawi, reported in Masangano and Miles 2004).

In some cases, lead farmers may be chosen to host a demonstration plot where other farmers can come to learn about the new seed and evaluate variety traits, thereby creating demand.

Another common method used in RTB systems as a delivery mechanism for improved planting material is the decentralized multiplication of planting material. This often involves trained farmers multiplying planting material at selected secondary and tertiary multiplication sites close to farmers. This approach may or may not involve the use of a voucher system to compensate the seed multipliers and make their endeavors profitable. For example, in its "Orange-fleshed sweetpotato" project, HarvestPlus (2012)

justified the use of the voucher system to introduce vines by stating that “commercially oriented vine multiplication schemes are preferable because they are more sustainable due to the profits they generate.” In addition, vouchers can be partially subsidized, or can simply be used to disseminate planting material in an orderly, transparent, and accountable way (Walsh 2011.). There are, however, debates regarding the efficacy of vouchers to bid to commercialize seed systems. Vouchers may subsidize the system, but once a project ends the sustainability of a system based on vouchers is not guaranteed. Furthermore, where a voucher system involves farmers paying part of the cost, other social norms may prevent farmers from gaining from the voucher scheme. For example, Ogero et al. (2015) state that although farmers were willing to pay the partial amount to access planting material (in a sweetpotato project in Tanzania, where farmers were asked to pay 17% of the total cost of the planting material), in areas where there were strong social norms against selling of planting material some farmers were unwilling even to pay this.

But if not properly managed and monitored, delivery mechanisms that depend on participatory activities can be gender blind, as when interventions based on participation do not recognize the differences between men and women. Gender-blind approaches “make assumptions, which leads to a bias in favor of existing gender relation ... gender blind policies tend to exclude women” (March, Smyth, and Mukhopadhyay 1999). For example, most delivery mechanisms in RTBs depend on farmer training to produce quality seed; however, men and women may not have similar access to training. For instance, earlier studies in eastern Nepal showed that only 12% of those attending extension demonstrations were women (Maskey 1993, cited in Gurung and Gurung 2002). Furthermore, demonstrations were held in men’s fields, which generally tended to have better soils than did women’s fields. Therefore, the results of such an exercise may not benefit women working on marginal soils. Mudege (2008) highlighted a similar practice in Zimbabwe, where within HH women were often allocated the least fertile plots (*shapa*/sandy soils) to plant crops such as groundnuts (regarded as women’s crops), consistently resulting in poor yields. In addition, when women attend the training sessions or demonstration plots, it is not always obvious that they will benefit at the same level as men. For example, Mudege (2007) notes that women predominated among those who cooked, cleaned, and provided entertainment during field days while men sat and listened to what the extension officers had to say.

Conlago et al. (2011) rightly notes that innovation processes may not benefit men and women equally. Men usually have better access to external information and play a greater role in decision-making during innovation processes. Research-and-development approaches seldom include gender-specific tools to encourage women’s participation. For instance, selecting lead farmers for training and seed dissemination may lead to gender biases if care is not taken to understand who the lead farmers are. For instance, though it is unclear how lead farmers are selected, a project by the development fund in northern Malawi noted that out of 25 original lead farmers, only 2 were women (Wellard 2011). In addition, HH power relations related to decision-making about food and access to and control of food may have an

impact on seed multiplication projects. For example, they may determine who can participate as host farmer (or producer of seed) and who can participate as a buyer of improved seed.

The delivery channels should be designed in ways that assure women the best access to planting material and associated knowledge, as well as promote their ability to be successful as commercial producers of quality planting material. Before any intervention, gender relations as well as norms and values embedded in a certain social context have to be understood so that women's access to quality planting material is not only with women as buyers of seed but also with their participating in the production and distribution of quality seed. But as noted by CRS (2012) with GLCI, sometimes gender studies are not given priority at the beginning of projects, thus weakening their ability to be used as input to improve program implementation.

2.2.2 *Affordability/Profitability issues*

Discussions on affordability or profitability are usually related to the semi-commercialization or commercialization of seed system. For example, Walelign (2008) notes that the biggest problem for the seed multiplication programs in Africa are the lack of sustainable seed markets for small farmers who produce seed. Staver et al. (2007 cited in Labarta 2009) state that

in the case of roots and tubers in the African region, the development of sustainable seed systems has posed many challenges to many countries. On one side, root and tuber planting material is considered a public good given its vegetative propagation, which creates little incentives for a wide appearance of private seed suppliers, but on the other side, seed systems in Sub Sahara Africa constantly face natural and man-made disasters that undermine the sustainability of seed production in the region.

Farmers' willingness to pay needs to be carefully considered when developing seed systems.

It is generally agreed that when discussing issues related to accessibility, it is also desirable to know the intensity of seed production—how much of a farmer's land is set aside for seed production and multiplication (Walelign 2008). Knowing this could possibly provide a measure of whether seeds are accessible since adoption may be linked to accessibility of a particular seed. However, there is also need to go beyond this to understand the gender dimensions of accessibility, especially those related to who controls the land that is put under seed multiplication, and who gains and who loses. Gender analysis of seed management and marketing would help to understand the roles and benefits of men and women in seed management. For example, women may not own land or may have access only to marginal land. This may affect who is likely to benefit from commercialization of seed system. In a study on potato seed systems in Malawi, Mudege et al. (unpublished) noted that "both men and women farmers expressed the willingness to pay a higher price for good quality but women were likely to mention a lower affordable price than men." Women farmers generally mentioned that they could not afford higher potato seed prices; instead women preferred noncash payments for seed than men did.

FAO (2008) acknowledges that commercialization of agriculture tends to exclude women. Women are usually excluded because they lack the resources needed to participate in commercialized systems.

Therefore, suggestions of commercialization, particularly of seed systems, need to be evaluated from a gender perspective in order not to harm women (Gibson et al. 2009). For example, experiences from other crops have shown that commercialization can result in the displacement of women from producing crops that were previously in their domain. In one such instance, Fischer and Qaim (2012) note that in Kenya, when the banana sector that was traditionally under women was commercialized due to increased demand for bananas, banana production was “centralized under men’s control” and women lost their source of income. However, this is not to suggest that women will not benefit from commercialization. There may be need for them to be targeted with training at the same rate as men for them to be able to take advantage of, participate in, and benefit from new commercial systems that may arise because of seed systems interventions.

2.2.3 Information

Active participation in seed systems is related to access to information with which farmers become aware of new improved crop varieties. Hagenimana et al. (1999) evaluated the effect in Kenya of women farmers’ adoption of orange-fleshed sweetpotato (OFSP) in raising vitamin A intake. Their study found that women farmers were likely to adopt OFSP if they were introduced through community-level education programs that focused on the health of young children. In fact, this approach of demand creation has been in many sweetpotato projects that demonstrate recipes and different way to cook sweetpotato or to process it into chips and biscuits (Attaluri, Janardhan, and Light 2010). OFSP programs, including big sweetpotato programs such as Mama SASHA (Sweetpotato Action for Security and Health in Africa) in SSA, provide unique and excellent examples of where there was a total focus on information systems using different types of media that drove the delivery channel investment. Most of the OFSP projects, both in Asia and Africa, have a very huge nutrition component, which makes it easier to target women.

When it comes to agriculture and crop production, however, access to information is not always assured for both men and women. As has been discussed earlier, women may not have access to extension services at the same level as men. Where they do, gender norms may dictate the quality of their interaction with extension officers and their ability to benefit from new information. Galiè (2013), in a PPB program in Syria, noted that the male government extension workers worked through HH heads (men in most cases). In addition, the extension officers threatened women who voiced dissatisfaction with their lack of participation in decision-making with dismissal from the groups. For example, extension agents discriminated against women farmers as host farmers by not involving them or, when they were involved, did not give them the same support and help they gave male farmers. In the Himalayas, Gurung and Gurung (2002) note that women are less likely than men to be recipients of training services. The HarvestPlus (2012) “Orange-fleshed sweetpotato” project in Uganda and Mozambique ended up including all those who wanted to work with them instead of working only through HH heads, in order to ensure that both men and women benefited from their project. This project provides an excellent example where “self-selection,” as opposed to using gender-biased pre-

selection criteria, was used to promote women's participation. Thus poor guidelines and poor supervision of extension workers and their lack of ability to work with women may disadvantage women in terms of access to knowledge and technology.

2.3 KNOWLEDGE ON SEED QUALITY

There are many reasons that have been cited for low productivity in agricultural crops, key among them poor-quality seed. Technocratic approaches usually point to three critical factors affecting use of quality seed by farmers: (1) the biophysical factors related to seed degeneration and seed availability; (2) seed management practices and multiplication technologies seed system actors such as NGOs and private and public sectors; and (3) farmers' willingness to pay for quality seed (Ortiz et al. 2012). While having disease-free planting material is essential for varietal quality, these factors are key. Yet there are factors that affect varietal quality that go beyond these three factors. Consequently, the component on knowledge on seed quality involves ensuring that disease-free quality planting material that meets other farmer and market preferences are available. Furthermore, effective and reliable diagnostic tools and methods to ensure maintaining seed health and purity need to be developed and used by both researchers and farmers. The framework advocates for developing farmers' capacity to manage quality planting material.

In their study, Gurung and Gurung (2002) state that lack of effective means to protect seed against pests during storage, as well as deteriorating knowledge of seed management (for grain crops), resulted in poor seed quality and low productivity. The authors highlighted the problems of accessing seed as "inconsistent supply, uncertainty about seed quality and the sources." The same also applies to vegetatively propagated crops such as those in the RTB family as, for example, noted in Reddy (2007):

The repeated use ... of seed by smallholders, however, can lead to seed degeneration. ... The common result of hundreds of millions of farmers repeatedly sourcing seed informally is inferior seed quality, dissemination and build-up of seed-borne diseases, and crop yields far below their potential.

Seed supply from both formal and informal systems suffers from these and other problems caused largely by lack of investments in education, research, and quality control programs. The 9th Triennial APA Conference noted that lack of clean planting material, irrigation, developed marketing structures, as well as little investment in research on new varieties are key challenges to sweetpotato production in SSA.

Moyo et al. (n.d.) suggest that lack of seed certification in cassava and sweetpotato could explain why disease-infected material is sold and distributed in many developing countries. Although certification could guarantee good quality seed, evidence from other crops have shown that in some cases women are less able to benefit from certification schemes than men (Spence 2012). Others have advocated for quality declared seed (QDS), which will improve seed quality. However, many developing countries are plagued by lack of government workers to monitor and inspect seed. For example, in Malawi the Seed Services Unit (under the Department of Agricultural Research Services) is responsible for seed certification and quality control. Although there is a seed certification scheme, Mloza-Banda et al. (2010) note that there are fewer government seed inspectors than required, and that the scheme is crippled by lack of

infrastructure and laboratory equipment as well. This may prevent seed interventions from introducing QDS protocols and also implementing and using reliable diagnostic tools and methods to ensure that seed health and purity are maintained.

Varietal quality should also be judged from the farmers' perspective. PVS has been the cornerstone of participation for men and women in integrated seed systems. PVS allows farmers to give input into seed development and to integrate them into formal seed systems (see also Zimmerer 2003). Women and men farmers need to be involved in seed systems so that seed is relevant to local conditions. Gurung and Gurung (2002) note that in the Himalayas, although the Agriculture Input Corporation distributed seed in the form of mini-kits, "farmers expressed uncertainty about the quality of the seed on the basis of their poor performance under local conditions." Farmers may continue to use seed in the informal system because few "cultivars and varieties on offer in the formal seed sector" meet their need (Reddy et al. 2007). Kaguongo et al. (2012) note that "the mismatch between technology characteristics and farmers' technology preferences has also been identified as the most important factor for the low level of technology adoption in Ethiopia."

Gender is also a critical consideration in determining variety quality. Research has shown that "gender related differences in evaluation techniques and criteria" (McElhinny 2007). "Women often use a broader set of selection criteria than men, since they use plants in more diverse ways" (Howard 2003). Thiele et al. (2014) note that in Malawi, OFSP trait evaluation criteria did not include women-preferred traits (such as the lobe-shaped leaf of the 'Zondeni' variety because it did not take long to cook). This meant that highly ranked varieties did not include this trait, and that 'Zondeni', which women preferred because of the leaves, was ranked low in variety trials and trait selection that involved farmers. Whereas men generally focus on criteria related to agronomic characteristics and market value, women apply additional criteria related to food consumption, such as palatability, taste, and cooking qualities (cited in FAO n.d.). The need to integrate a gender perspective into seed systems can hardly be overemphasized.

2.4 SUSTAINABILITY/RESILIENCE AND EQUITY AND GENDER

Although the sustainability pillar is concerned with how to stimulate rapid multiplication of propagation, the gender pillar is loosely defined to mean women's involvement in seed multiplication and their knowledge of RMTs. Yet, the understanding of sustainability/resilience is somewhat limited. For issues of environmental sustainability, which are critical in agriculture—particularly in many RTB crops—are not addressed. Sustainability should be expanded to include issues related to environmental sustainability. The framework should broaden understanding of gender and equity issues to include knowledge that men and women have and how they participate in ensuring quality seed, including their involvement in decision-making and ability to benefit from seed systems and marketing. This expanded definition of sustainability/resilience, equity, and gender acknowledges that seed systems must not only be environmentally sustainable, they also need to ensure that both men and women benefit and neither is harmed.

2.5 POLICIES AND REGULATIONS

The framework focuses on both formal and informal policies and regulations. Policymakers, for instance, are involved in policy change, development, and implementation that include variety release issues, whereas the behavior of seed users and seed producers are governed by policies that are enacted to protect the quality of planting material. The framework does not differentiate between formal and informal policies and regulations. This approach to understanding policies and regulations makes them very abstract and fails to acknowledge the informal policies and regulations that regulate people's behavior at the local level. There may be local informal norms that regulate conservation, use, and exchange of seed. Galiè (2003) suggests that informal rules should include norms and customs, as these influence how people act and, to some extent, governs how people access seed. If informal rules are understood from this perspective, it makes it easier to understand gender norms and perspectives that affect seed use and access at the local level.

3. Discussion

There is a great need to integrate gender into seed system development and intervention, not only to ensure that both men and women's needs are taken into account, but also to increase uptake of appropriate seed technologies and to improve food security. But this should also involve understanding of the social systems and cultural norms governing how the different stakeholders act. The multi-stakeholder framework for intervening in RTB seed systems is largely silent on this issue. The importance of social structures in determining participation in and benefitting from seed systems need to be understood. The framework partially addressed the social and structural configurations but it does not address structural issues related to gender. For example, the preceding analysis clearly shows the importance of understanding social structural factors related to gender relations and how society is organized. Gender relations "create and reproduce systematic differences in men and women's position in a given society...They define the ways in which responsibilities and claims are allocated and the way in which each is given value" (March, Smyth, and Mukhopadhyay 1999). Gender norms and cultural expectation and biases may affect how the different stakeholders deal with women farmers. For example, as noted in an earlier example in which women were systematically excluded and discriminated against participation in PVS systems for wheat and barley in Syria (see Galiè 2013). Thus even when the seed is available, women may not be able to benefit from it since it may not meet their needs and they may not be able to access it.

Although the multi-stakeholder framework for intervening in RTB seed systems is useful in identifying key themes for data collection, as well as the key stakeholders involved, as designed it is not particularly useful in data analysis from a gender perspective. For example, although the framework took account of context and structural factors (e.g., policies and regulations), it did not examine local-level structures very well. The framework has an implicit ideological assumption that markets are inherently beneficial in terms of access to good-quality seed as well as profits from seed marketing (cost-benefit analysis);

however, it does not give enough attention to social factors that may restrict men and women from participating and benefiting from seed markets. The framework focuses on how interventions affect access to seed or seed quality but fails to take into account how interventions impact social formations, including gender relations.

In addition, the framework's understanding of sustainability/resilience is somewhat limited in its concept of issues dealing with environmental sustainability that are critical in agriculture. The seed systems framework should go beyond this limited perspective. Gender and gender equity issues should be expanded to include knowledge (indigenous knowledge, too) that men and women have and how they participate in ensuring quality seed, including their involvement in decision-making and ability to benefit from seed systems and marketing. This expanded definition of sustainability/resilience, equity, and gender acknowledges that seed systems need not only be environmentally sustainable. Seed systems also need to ensure that both men and women benefit and do not harm either group.

Certainly, the framework strengthens the feedback link between farmers and scientists. Yet by focusing on top-down approaches to knowledge dissemination and training, it is limited by not recognizing the indigenous knowledge that farmers may have. The role of the formal-sector stakeholders in maintaining seed quality is carefully articulated. Examples include policymakers who will develop policies to prevent cross-border movement of infected seed as well as deal with variety release issues; researchers who deal with development of effective and reliable diagnostic tools; seed producers who develop seed models and multiply rapidly clean seed from research institutions; and seed users—who are mostly farmers—who need to have their capacity built in order to use and manage planting material. The framework is geared toward demand creation by developing seed that meets farmer needs; however, farmer knowledge is neither recognized nor acknowledged.

It is clear that frameworks to understand seed systems also need to understand gender and cultural norms related to resource distribution that may affect the ability of men and women to benefit. Therefore, seed system interventions should take this into account. For example, when women own or are allocated the least fertile and marginal lands to use, trials conducted on plots managed by men may not address women's particular needs. Thus for women to benefit from seed systems, the resources available to them also need to be understood. The multi-stakeholder framework for intervening in RTB seed systems does not take into account social cultural and informal norms governing seed systems. There is opportunity to integrate some social norms and the informal rules and regulations governing local seed systems under the pillar that discusses informal policies and regulations. To do this, though, the framework needs to have a more nuanced distinction between formal and informal regulations.

From the review the following questions have been identified as a starting point to conduct a gender analysis of seed systems. The questions should be applied so as to understand the differences and similarities between men and women's participation in seed systems:

Question related to availability and supply

- Why farmers grow the crop—feed or fodder?
- What are the seed sources for men and women (e.g., saved, local seed exchange, government, private sector, buy, borrow, etc.)?
- What are the constraints men and women farmers face in accessing seed? Are these constraints different or the same?
- What are the methods of maintaining planting material, including seed selection, storage, and vine multiplication?
- What is the quantity of seed/vines produced and sold by individual farmers (both men and women); how much do they pay for the seed?
- How do farmers market their seed? Who does the marketing (men and/women), and where are the vines marketed?
- What is the farmers' economic status? Do HH characteristics such as whether a house is headed by a male or female matter in access to seed for men and women farmers within those HH?
- Is seed supply stable over time, or do people experience acute or chronic seed shortages?
- How do local men and women define seed security? Is seed assured for the crop under study?

Accessibility

- What is the level of awareness of improved varieties, including characterization of these varieties? Are there any differences in level of awareness between men and women?
- How do preferences differ between male and female farmers? How are these taken into account in seed systems?
- Who attends awareness training? How is the awareness training structured, and how are participants recruited?
- Who is targeted by capacity-building workshops (e.g., on crop production aspects, integrated pest management, seed health management, etc.)? Are there differences between men and women in the topic presented? Are capacity-building approaches suitable for men and women?
- Can men and women afford quality seed, and are they willing to pay for it?
- How involved are men and women in the distribution of breeder seed (PVS)? To what extent are they involved? What are the constraints and opportunities?
- Where do men and women source their seed? What are the linkages with the formal system? What are the perceptions regarding accessibility of different seed systems by men and women?

Variety quality

- How do men and women define “varietal quality”—are there differences and similarities?
- What are the constraints and opportunities related to supply and access to good-quality seed? Are they similar or different for men and women?

- From whom do men and women get quality seed?
- What do men and women know about varietal quality? Are there differences between men and women in terms of varietal diversity? Are there any differences across socioeconomic groups?
- Who are the “nodal” farmers in terms of distribution of new seed and information about new varieties? Are these farmers male, female, or both? What are the differences with other farmers?

Social systems and cultural norms

- What are the gender and cultural norms that mediate access to seed?
- Who decides on the management and resource allocation of different crops? Who is responsible for seed selection, treatment, and storage, and for seed multiplication and exchange?
- How do gender norms permeate the interface between farmers and outside institutions and stakeholders?
- How does access to different resources determine ability to influence seed system governance for men and women? How does gendered distribution of resources affect women’s ability to participate and benefit?
- What are the gender differences in the availability of and access to land; do they own or rent land? How much land do they set aside for the production of RTB, and with what yield from improved varieties compared with farmer varieties?
- What are the legal provisions governing the seed system, and how do these affect male and female farmers?
- What are the implications of involvement in vine multiplication activities on other crops or varieties?

Additional questions

- What are the demographic characteristics of seed producers?
- What is the intensity of cropping and adoption of improved varieties/or engagement in vine multiplication?

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