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CGIAR Gender & Breeding Initiative

Working Paper 3

State of the Knowledge for Gender in Breeding: Case Studies for Practitioners

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CGIAR Gender and Breeding Initiative Working Paper

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ISSN 2309-6586
DOI+ISBN

Correct citation:
Tufan, H.A.; Grando, S. and Meola, C. (Eds.). 2018. *State of the Knowledge for Gender in Breeding: Case Studies for Practitioners*. Lima (Peru). CGIAR Gender and Breeding Initiative. Working Paper. No. 3.
Available online at: www.rtb.cgiar.org/gender-breeding-initiative

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ACRONYMS

ACGG	African Chicken Genetic Gains project
ADMARC	Agricultural Development and Marketing Corporation
CE	Choice experiment
CIAT	International Center for Tropical Agriculture
CIP	International Potato Center
CRPs	CGIAR Research Programs
CSB	Community seed bank
ESA	East and Southern Africa
FEAST	Feed Assessment Tool
FGD	Focus group discussion
GBI	Gender and Breeding Initiative
GREAT	Gender-Responsive Researchers Equipped for Agricultural Transformation project
ICARDA	International Centre for Agricultural Research in the Dry Areas
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
IITA	International Institute of Tropical Agriculture
ILRI	International Livestock Research Institute
LCM	Latent class model
MASFA	Mchinji Area Smallholder Farmers Association
NARO	National Agricultural Research Organization
NARS	National agricultural research systems
NASFAM	National Smallholder Farmers Association of Malawi
OPVs	Open pollen varieties
PABRA	Pan-African Bean Research Alliance
PPB	Participatory plant breeding
PVS	Participatory variety selection
RPL	Random parameter logit
RTB	Roots, Tubers and Bananas
SAPs	Structural adjustment programs
SSA	Sub-Saharan Africa
SUA	Sokoine University of Agriculture
TALIRI	Tanzania Livestock Research Institute
UPAs	Units of agricultural production

PREFACE

For plant and animal breeders to meet users' needs, they need to understand the priorities that women and men assign to genetically determined traits, such as taste, color, size, and shape. Many CGIAR breeding programs know that if they overlook traits important to women users, this can aggravate household food insecurity and poverty. However, breeding programs still do not have enough practical methods and tools to help practitioners decide how to be more gender responsive and consider gender differences in breeding schemes. Tackling this knowledge gap is urgent if CGIAR Research Programs are to achieve the targets for gender equality defined in the CGIAR Strategy and Results Framework.

In response, the CGIAR Gender and Breeding Initiative (GBI) was launched in 2017, building on a strategy developed by an interdisciplinary group of breeders and social scientists who came together in 2016 as part of a workshop on "Gender, Breeding and Genomics" convened by the CGIAR Gender Network (which has now evolved into the CGIAR Collaborative Platform for Gender Research led by the CGIAR Research Program on Policies, Institutions and Markets).

GBI brought together this same group of scientists in October 2017. The aim was to build on this earlier work and develop recommendations for practical ways to improve the gender responsiveness of breeding programs; evidence-based methods and tools for gender-responsive targeting, implementation of breeding activities, and linkage with variety dissemination; and support a community of practice for active sharing and development of methods and tools.

This case study synthesis is part of a series of knowledge products designed to share the outputs from the 2017 "Innovation in Gender-Responsive Breeding" workshop, and to share GBI's collective knowledge more widely across CGIAR and partner breeding programs.

GBI is coordinated by the CGIAR Research Program on Roots, Tubers and Bananas (RTB) and the International Potato Center, with funding support from CGIAR fund donors.

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ACKNOWLEDGMENTS

We thank the authors and co-authors of the case studies. All responded promptly to the idea of this synthesis and worked enthusiastically with us against a very tight timeline. We hope you will find this synthesis helpful and a source of inspiration to design and implement a gender-responsive breeding program. We are aware that this synthesis is far from being exhaustive and many more cases are out there. We look forward to your inputs, comments, and suggestions. We are grateful to Alessandra Galiè, Merideth Bonierbale, Eva Weltzien, and Michel Ragot for their review and comments.

FOREWORD

We believe many breeders in the public sector chose the discipline because they are driven by a desire to help people. The proposition that new varieties can, in fact, help farmers provide food to more people and increase the sustainability of our agriculture is, however, surprisingly contested. For example, arguments that Green Revolution varieties helped larger farmers but hurt subsistence farmers get more air time than arguments in favor of increasing varietal productivity. This begs the question, what steps can breeders take to ensure that breeding products have more equitable outcomes?

We also believe gender scientists are driven by a sense of justice and a concern for people in vulnerable or disadvantaged social categories. A challenge in the agricultural and natural resource sectors is to meaningfully engage with biophysical scientists and to find entry points that make sense for both the social and technical dimensions of the problem at hand. Understanding the origins and consequences of the power and knowledge differentials between social categories—men and women being one of the biggest—is a central part of gender analysis. But oftentimes, efforts to bring out the social dimensions in biophysical research are met with resistance or lack of understanding. One of the greatest challenges for gender scientists working in the aqua/agricultural and natural resource domains is, *how can we make gender analysis meaningful for biophysical scientists?*

Integrating gender analysis into breeding requires both motivated breeders and motivated gender scientists. Beyond understanding different jargon and different categorizations of knowledge, they brave the interface between the two disciplines and must be confident that this holds value for advancing their research. Breeders need to believe that a gender-responsive approach will lead to greater adoption of their varieties. Gender scientists need to be ready to explore how the (perhaps) "blunt instrument" of varietal differences may affect gender relations. This case study synthesis illustrates different ways of navigating the gender-breeding interface and gets to the nitty-gritty details of how gender analysis is relevant for breeding. The 10 case studies presented in Chapter 3 show that gender integration is a dialogue between the breeders and the gender specialists, who together break new ground. They offer kernels of evidence that the hard work of finding relevant entry points, of creating a common language, and of understanding each other's field of inquiry has the potential to improve both the breeding, and the equity of its development impact.

That said, the case studies offer no guarantees. Nor do they test in a statistically rigorous way the proposition that the gender-responsive approach to breeding has a different impact than a counterfactual "gender-blind" approach. But what they do very nicely is start to develop a framework to guide breeders and gender scientists in thinking together; they offer inspiration and signposts to guide future interdisciplinary efforts. In effect, they offer a different way of approaching breeding and a new paradigm that challenges ideas as to what is possible and how to get there. And, ultimately, they entice us to dig deeper; to move beyond aspirations and anecdotes to rigorously test whether the outcomes of gender-responsive breeding will indeed prove to be more (gender) equitable.

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EXECUTIVE SUMMARY

Debates around gender-responsive agricultural research, particularly plant and animal breeding, invariably circulate around similar topics: the recognition that considering gender is important to developing varieties that lead to equitable benefits, coupled with questions around an evidence base that proves this point. Without convincing evidence—exemplified by case studies across commodities and countries—our arguments for gender-responsive research fall on deaf ears.

This synthesis seeks to compile available cases from two workshops organized by the CGIAR Gender and Agriculture Research Network: "Gender, Breeding and Genomics" (18–21 October 2016) and "Innovation in Gender-Responsive Breeding" (5–7 October 2017). While by no means comprehensive, with these 10 cases we hope to emphasize the point that considering gender in breeding program design, working with women in the breeding process, and acting on these findings can have dramatic consequences on breeding programs.

We begin the synthesis by setting the scene with a chapter reflecting on how taking gender into account matters for the success of plant or animal breeding programs with welfare or development goals and a focus on smallholders. This chapter illustrates how the use of a conceptual framework for gender analysis can help breeding programs make sense of gender-differentiated traits and tease out the likely impact of taking gender into account in program-level policies and strategies.

The following case studies are structured around steps of a plant breeding cycle (see Figure 1.1), examining cases that consider gender in setting breeding priorities, selection, testing experimental varieties, and seed production and distribution. The cases cover a wide range of commodities: beans, cassava, forage grasses, poultry, maize, sorghum, *matooke*, barley, and groundnuts. Although cases mostly focus on sub-Saharan Africa (Nigeria, Mali, Tanzania, Uganda, Ethiopia, Malawi), we also present cases from China and Syria.

What is particularly compelling about these cases is that they not only provide evidence that men and women have different trait preferences; access to resources; or opportunities to engage in production, processing, and marketing of diverse commodities. They also illustrate steps taken by breeding programs to address these issues. These steps range from incorporating "cooking time" as a must-have trait in bean breeding to creating opportunities for maize seed production and sale for women; from changing the structure of *matooke* breeding programs to add participatory processing for food quality, new breeding targets for adaptation, to nutrient poor soils in sorghum. These are powerful illustrations and positive examples that documenting differences is a means to an end—the real focus should be on change. The synthesis ends with a chapter drawing lessons from the case studies for future action aiming to integrate gender and gender analysis in breeding.

We hope that these cases, together with the companion publications from the GBI on design principles[1], gender and social targeting[2], breeding decisions[3], and uptake pathways[4], compel and challenge breeding programs to become truly gender responsive.

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[1] http://www.rtb.cgiar.org/gender-breeding-initiative/activities/design-elements-for-gender-responsive-breeding/
[2] https://cgspace.cgiar.org/bitstream/handle/10568/91276/Working%20Paper%201_STP_FINAL%20VERSION_18_02_08.pdf?sequence=1&isAllowed=y
[3] https://cgspace.cgiar.org/bitstream/handle/10568/91290/GBI%20BRIEF%201.pdf?sequence=1&isAllowed=y
https://cgspace.cgiar.org/bitstream/handle/10568/91275/Working%20Paper%202_BreedingObjectives_FINAL%20VERSION_18_02_13.pdf?sequence=6&isAllowed=y
[4] https://cgspace.cgiar.org/bitstream/handle/10568/91291/BRIEF-GBI-2-Uptake%20Pathways.pdf?sequence=1&isAllowed=y

State of Knowledge for Gender in Breeding: Case Studies for Practitioners

1. INTRODUCTION

Widespread adoption and impact of new crop varieties and animal breeds on resource-poor farms depend on the tangible benefits these provide for the women and men involved in their production, consumption, and marketing. To meet users' requirements, it is critical for breeders to understand and respond to the needs, priorities, and constraints in production, consumption, processing, and marketing that women and men assign to crop and animal products. Taking into account gender dynamics and sex-disaggregeted preferences will make it more likely that farmers will adopt new varieties and breeds that will help strengthen food and nutrition security.

For a breeding program, taking gender into account means putting into practice the four principles of gender-responsiveness summarized in Box 1.1.

Box 1.1 What can a breeding program do to be gender-responsive?

- Know when, where, and why women and men are important and often distinct beneficiary groups. Take into account important differences in constraints faced by women and men farmers that breeding can influence.
- Anticipate how design decisions (e.g., defining plant ideotype, prioritizing of traits, targeting and testing varieties with farmers) may impact and be influenced by gender dynamics in communities and households, affecting for example, women's labor, available resources and opportunities.
- Design breeding objectives specifically to benefit women farmers when they are an important beneficiary group who require a special approach, and consider their needs, constraints and knowledge more generally in the breeding program.
- Be accountable, making sure the success of the breeding program is measured in ways that include positive impacts for women, men, as well as for households or farmers in general.

Source: Gender and Breeding Initiative Brief No. 1[1].

Many CGIAR breeding programs recognized long ago the need for crop and animal breeding programs to consider gender differences, and have understood that if they overlook traits important to women farmers and consumers, they will not only further disempower these women, but also can aggravate household food insecurity and poverty. However, breeding programs still do not have practical methods

[1] https://cgspace.cgiar.org/bitstream/handle/10568/91290/GBI%20BRIEF%201.pdf?sequence=1&isAllowed=y

and tools to help them decide how to be more gender responsive and to understand the changes and the implications in breeding schemes.

With the aim of helping to reduce this major knowledge gap, the gender and breeding working group of the CGIAR Gender and Agriculture Research Network organized a workshop on gender, breeding, and genomics. The event, held in Nairobi, Kenya, on 18–21 October 2016, brought together a diverse group of experts in breeding, genomics, and social sciences that stimulated an active exchange of ideas, reflecting different perspectives and experiences. The workshop concluded that the knowledge and experience exist to construct, in a short time, a clear strategy for gender-responsive breeding with supporting methods, tools, and practices. This knowledge, however, is scattered in different sectors and disciplines and needs to be connected by a multidisciplinary team effort[2].

The CGIAR Gender and Breeding Initiative (GBI)[3] was launched to pull together this strategy for gender-responsive breeding with supporting methods, tools, and practices by the group of breeders and social scientists who participated in the 2016 workshop. The CGIAR Research Program (CRP) on Roots, Tubers and Bananas (RTB) and the International Potato Center (CIP) are coordinating this effort.

The 2016 workshop generated 13 case studies that form the basis of this synthesis (10 were ultimately chosen). Most were submitted in response to an open call; a few were identified and added after the call was closed. During the workshop, participants indicated the need to fully document and compile the cases as a set that could be consulted and referred to easily, and proposed to identify additional cases from extended search. The purpose of the case study synthesis is to identify illustrative cases of current approaches toward gender-responsive breeding programs and to highlight useful methods and lessons learned for practitioners.

The GBI committed to a synthesis of case studies from the 2016 workshop as one of the three input papers, in preparation for the "Innovation in Gender-Responsive Breeding" Workshop, held in Nairobi on 5–7 October 2017. A first draft of the synthesis was presented and discussed at the workshop; the comments and suggestions received were incorporated in the final design of the synthesis.

The case studies were originally analyzed around a framework outlining a generalized breeding cycle (Figure 1.1).

[2] https://cgspace.cgiar.org/handle/10568/78078

[3] http://www.rtb.cgiar.org/gender-breeding-initiative

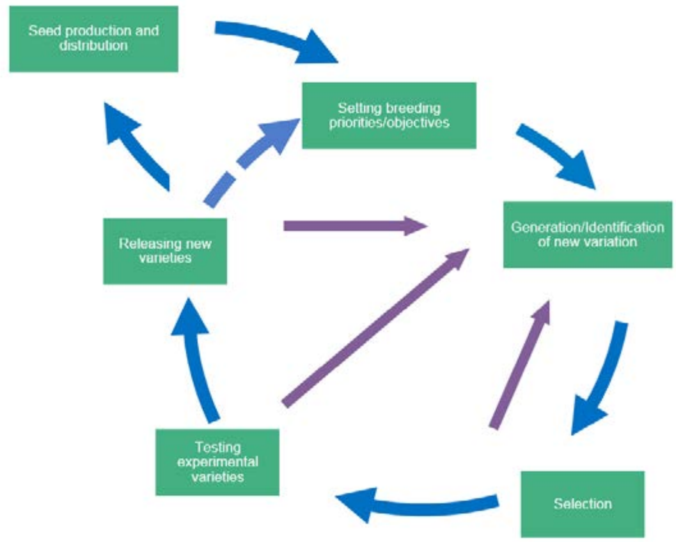

Figure 1.1 Main stages of a generalized breeding program (Grando 2016)[4].

In discussion for the preparation of this synthesis, we have added a new step of social targeting and demand analysis that informs setting breeding priorities. Figure 1.2 presents a scaffold onto which case studies presented in this synthesis are mapped, based on the stage in the breeding cycle when gender was integrated.

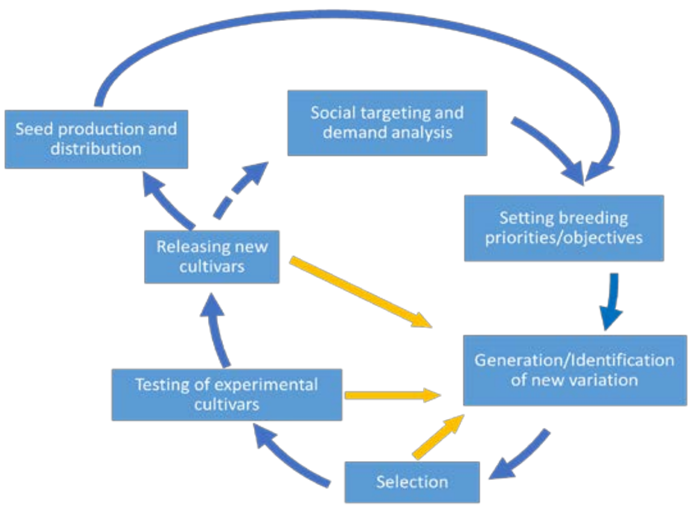

Figure 1.2 Modified version of the main stages of a breeding program, used to classify the cases.

The following questions guided the formulation of the format of the individual case studies:

1. What was the driver for carrying out research on gender (e.g., low adoption, literature showing important role of women in production, etc.)?

[4] https://library.cgiar.org/bitstream/handle/10947/4657/CGIAR%20Gender%20Research%20Action%20Plan-Breeding_Brief4.pdf?sequence=5

2. What have you learned generally in the process of this research? What would you do differently if you went back?
3. What would you recommend to researchers thinking to apply the same methods/approaches?
4. What have you changed in your breeding program as a result of your research on gender?
5. How has the breeding process itself resulted in community-level impacts, especially gender relations?

The case studies included in this synthesis, evaluated based on the criteria indicated in Appendix A and reviewed by the editors of this synthesis, mapped to four stages: Setting Breeding Priorities, Selection, Testing Experimental Varieties, and Seed Production and Distribution.

The use of a conceptual framework for gender analysis can provide support to breeding programs to understand gender-differentiated traits and the likely impact of considering gender in program-level policies and strategies.

Finally, we did not intent to have a compilation of case studies that could be representative of breeding programs in general. The cases were selected for their unique interest as examples of ongoing experience of considering gender in different stages of the breeding cycle. Therefore, we cannot generalize about practice from the case studies but can draw some suggestions for promising approaches and lessons learned.

2. RELEVANCE, ADOPTION, AND IMPACT: WHY GENDER MATTERS IN BREEDING

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Introduction

Chapter 2 provides a context for reading the case studies presented in Chapter 3. It explains why taking gender into account matters for the success of plant or animal breeding programs with welfare or development goals and a focus on smallholders. Nonetheless, the underlying principle, illustrated in the cases of "understanding the customer" and of analyzing why different types of users have distinct demand for new breeding products, is fundamental for success of any breeding program. This chapter illustrates how the use of a conceptual framework for gender analysis can help breeding programs make sense of gender-differentiated traits and tease out the likely impact of taking gender into account in program-level policies and strategies.

Taking Gender into Account

For a breeding program to take gender into account effectively requires understanding how differences in the roles and resources, power, and status of men and women affect their preferences and technology adoption decisions. It also requires a careful examination of how gender differences can influence the type and distribution of benefits among people the program expects will use its new varieties or animal breeds.

The effect of new technology on unequal workloads, resources, and decision-making power between men and women smallholders in low-income countries is pervasive (World Bank 2007; FAO 2011). The amount of work done by women in agriculture and their tasks vary considerably in different regions of the world. The introduction of new plant varieties and animal breeds, and the new management practices these require, frequently changes the type and amount of work to be done by different people (Doss et al. 2017). Shifts in labor use affect the social relations between men and women, whether working as unpaid labor on family farms, as hired labor, or as managers.

With different access to inputs, information, and markets, men and women producers make different choices about what to grow. Even if men and women are equally productive in farming a specific crop, women may systematically produce crops of lower value if their inputs are of inferior quality (wa Githinji et al. 2014). Lack of land rights can mean that women producers simply invest less in innovation (Goldstein and Udry 2008). When new varieties or animal breeds change levels of production, productivity, and marketable surplus, the relative importance and value of these crops or animals to different people also change (Doss 2018). How men and women benefit or lose out from such changes will be affected by their different levels of control over resources (Galiè et al. 2017b; Njuki et al. 2016). Different levels of control are governed by the norms, roles, and institutions that regulate gender relations.

When breeding programs select new varieties or crops or animal species or breeds, these will change how the production, income, and other benefits of the technology are captured by different social groups in positive or negative ways (Timothy and Adeoti 2006). For example, the introduction of more productive dairy cattle has been shown to often disadvantage women by increasing their work burden while decreasing their traditional control over milk revenues, as larger quantities transform milk into a commercial asset under the control of men (Njuki and Sanginga 2013; Galiè et al. 2017a). These effects of gender inequality on agriculture are not new, and supporting evidence has been generated by more than two decades of research that is continuously expanding (World Bank 2008). Yet, this body of evidence is not the same for all sectors: for example, research on land tenure has received more attention than examining how research processes can perpetuate gender inequality. The case studies presented in Chapter 3 add to the picture of gender differences in technology choice and provide accounts of how breeding programs have used this type of analysis to improve their gender responsiveness.

Gender inequalities are unquestionably pervasive and powerful in smallholder agriculture due to women's predominant responsibility for reproduction, childcare, and domestic labor as well as the low value placed on female compared with male labor across different regions of the world. However, taking gender into account does not mean focusing exclusively on ways in which women differ from men. The effect of gender on farmers' decisions, and what this means for breeding, cannot be accurately identified unless analysis takes into account the ways in which gender effects are qualified by other important social characteristics, including wealth, income, education, age, race, and ethnicity (Kilic et al. 2013). One reason is that wealth or education can mitigate the disadvantages of being a woman—for example, when well-educated women producers have more access to agricultural information than poorly educated men. In the same way, poverty and illiteracy can wash out gender effects (e.g., when very poor male producers are as unlikely to purchase improved seed as very poor female producers). In addition, women farmers may be lone decisionmakers, or they may farm jointly with other men or women in a household. The nature of such a relationship can fundamentally affect adoption (Gilligan et al. 2013). Simply analyzing the effect of being female—as when comparisons are made with sex-disaggregated data on what varieties or traits women versus men prefer or who does what farm management tasks—will shed light on whether and what differences exist between the sexes. But it will not necessarily tell you a lot about the effects of gender on technology choice. Simple sex disaggregation is seldom powerful enough for explaining or predicting social behavior in ways useful to breeding.

Essential for taking gender into account from the perspective of breeding is, therefore, the construction of an accurate, multivariate user profile that involves analysis of the differences among types of men and women users as affected by other social factors, such as income, wealth, and education[5]. Use of this profile to understand the importance of gender relative to other factors is necessary for acting on Principle #1 in Box 1.1 (above): "Know when, where, and why women are an important beneficiary group." Understanding the social factors underlying trait preferences is necessary for acting on Principle #2:

[5] A manageable approach to profiling users suitable for breeding programs is discussed in Orr et al. 2018.

"Anticipate how design decisions…. may impact and be influenced by women's labor, available resources and opportunities."

Gender-differentiated traits often cannot be interpreted unless they are associated with the picture of assets, resources, and risks provided by the social profile of the customer. Understanding the social profile and the economic importance of different user groups, including specific groups of women producers, is essential for a breeding program to decide whether to act on Principle #3: "Design breeding objectives specifically to benefit women farmers when they are an important beneficiary group who require a special approach." Breeding programs face many kinds of demand from different types of customers and must be selective about whose demand takes priority. Part of being gender responsive is to make informed decisions about the relative economic and social importance of breeding products that may be in demand by some women farmers but are beyond the scope or resources of the program to supply. Not all breeding programs will set out to specifically benefit women farmers, but all programs will make an implicit or explicit decision about whether to do so. Finally, acting on Principle #4 involves using the social profile built with gender analysis as a baseline and a source of indicators for "making sure the success of the breeding program is measured in ways that include positive impacts for women."

In sum, the essential actions for gender-responsive breeding identified in the four principles above (i.e., constraints analysis, setting objectives, design, and monitoring) all require reference to a social profile that includes (but is not limited to) analysis of differences between men and women. The next section discusses key components of a framework for social analysis that will be useful for interpreting gender issues confronted by breeding programs and illustrated in the case studies.

Making Sense out of Gender-differentiated Trait Preferences and Their Impact

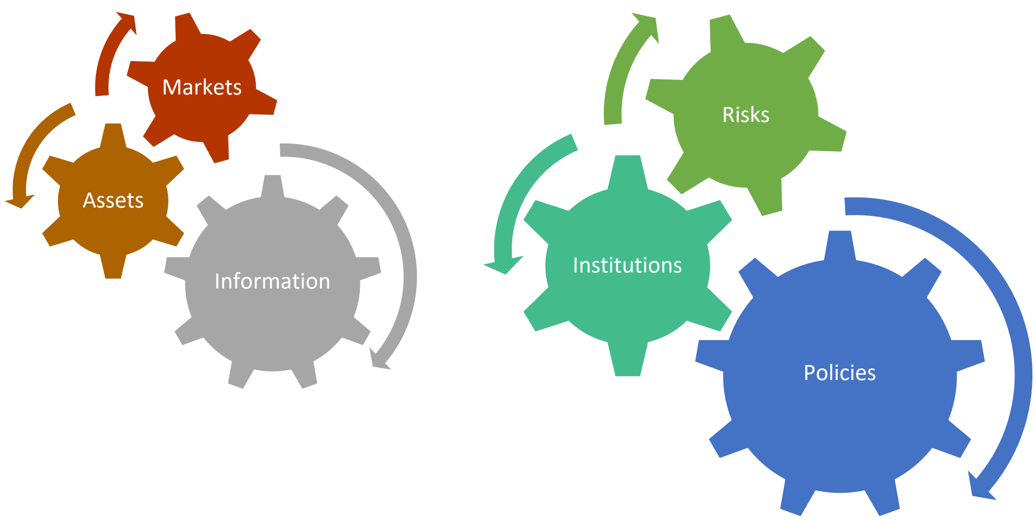
The framework for gender analysis presented in Figure 2.1 consists of six interdependent, interacting components that are widely utilized to conduct gender analysis, in a variety of arrangements: these are assets, markets, information, risks, institutions and policies[6]. This means that analysis of the effect of one component (e.g., assets) needs to consider the influence of the other components. To illustrate, let us examine how applying the framework helps to make sense out of gender differences in trait preferences that can often seem inconsistent or contradictory.

Characterizing gender inequalities in assets, markets, and risk is fundamental to understanding user demand for and adoption of breeding products, and their eventual impact on gender equality. Frequently, preference studies will throw up situations in which men and women have completely different trait preferences, other instances where their trait preferences are essentially similar, and yet others where both sexes consider the same traits important but in a very different order of priority (Christinck et al.

[6] Figure 2.1 is adapted from Figure O.I Sustainable Livelihoods through a Gender Lens, designed as the organizing structure for the *Gender in Agriculture Sourcebook, 2009. The World Bank, Food and Agriculture Organization (FAO) and the International Fund for Agricultural Development (IFAD). Washington, DC. The International Bank for Reconstruction and Development: Figure O.I p.5.*

2017). Simply assessing whether men and women agree or differ on trait preferences generates this apparently contradictory picture.

The golden rule for making sense out of gender-differentiated trait preferences is to look for the explanation of how these preferences reflect underlying gender differences in assets, markets, information, and risk, and the ways institutions and policies condition these. In other words, analysis is needed to interpret gender-differentiated trait preferences. This should use the components shown in Figure 2.1 to identify significant differences in the constraints and opportunities faced by men and women when they make decisions about use of breeding products. This is especially important for traits that might exacerbate or sustain harmful disadvantages that the breeding program can feasibly do something about. By understanding how trait preferences are causally linked to social differences, breeders can be better equipped to understand the impact of their work. They can then make decisions in the light of a forward-looking analysis of the potential social impact of a proposed change in plant varieties or animal breeds.



Legend	
Assets	Gender inequalities in access to and control over social, physical, financial, natural, human, and social capital
Markets	Gender inequalities in market participation and power in land, labor, finance, and product markets and in the distribution of risks and gains along value chains
Information	Gender inequalities in accessing information, extension services, training, participation in organizations, political voice, and freedom of expression
Risks	Gender inequalities in exposure to ecological, production, financial, health, and other components of vulnerability
Policies	Gender inequalities in strategies and actions that directly influence access or use rights, value, or prices
Institutions	Gender inequalities expressed in informal rules or norms, role responsibilities, formal standards, regulations, and laws

Figure 2.1 Interdependent components of gender inequality

The case studies in Chapter 3 supply several illustrations of how different trait preferences are associated with gendered asset inequalities. In the *Participatory Sorghum Breeding Mali* case study, women expressed preferences for varieties tolerant of low soil fertility. Further study showed the poor performance of varieties on women's plots was associated with late flowering in response to low levels of P in the soil, a widespread constraint in West Africa. The preference expressed by women reflects the underlying structure of gender inequality in land rights and land access, which determines that women have lower access than men to fertile land, manure, and fertilizer in this farming system. Empirical evidence of a generalizable gender gap in soil quality is scarce and inconclusive but unequal land rights are a powerful driver of gender differences in trait preferences (Gladwin 2002; Nkedi-Kizza et al. 2002; World Bank 2014). Once breeders understood that women are allocated the less fertile plots, they did not try to change unequal land rights, but proactively acted to decrease gender inequality by developing varieties with improved tolerance for low P which were particularly beneficial for women producers.

In the *Ololili Tanzania* case study, men gave higher importance to livestock fattening, whereas women gave higher importance to milk production. This reflects asset distribution because men own the animal while women control the other relevant asset, milk. In a situation like this, breeders may face a tradeoff and must make a choice: whether to prioritize breeding animals that gain weight quickly, or prioritize animals that, first and foremost, produce a lot of milk. That choice is also a decision about how to take gender into account. In a different situation, studies find that women have little incentive to prioritize milk production when they lack control over milk and milk income, even if they have rights and responsibilities related to dairy management (Johnson et al. 2015). The *Cassava Nigeria* case study found broad agreement on cassava traits between women and men associated with similarity in their uses and labor input for cassava. When their farm labor responsibilities differ, this will be reflected in men's and women's varietal trait preferences. For example, evaluation of Nerica rice varieties in Ghana, Togo, and Guinea showed that men favored quick-growing cycles and short plants. Women, though, preferred good emergence and seedling vigor because they are responsible for sowing and weeding. The *Poultry Ethiopia* case study found men and women expressed similar preferences for physical poultry traits; however, the weight given to traits differed between men and women and reflects both unequal assets and uneven market participation. Male producers focused on productivity and health with the objective of scaling up to an intensive, commercial scale of production. Most female producers wanted to keep any increase in the scale of production at household level, and thus valued the traits that allowed chickens to be kept in an extensive system while increasing productivity. Women lacked scope to increase labor and invest in the infrastructure required to keep chickens at a commercial scale. These gender-differentiated trait preferences may be taken into account in decisions made by a breeding program about what type of plant or animal and production system to support or promote.

All the cases cited so far relied on sex-disaggregated comparisons without factoring in other socioeconomic characteristics, such as wealth or education, and as the case studies show, access to other resources such as rural electricity. The case study of *Beans East Africa* analyzed differences in demand for traits among consumers, using an approach to build the kind of multivariate user profile (for consumers) recommended above for profiling producers. Rather than simply comparing men and women, this analysis profiled segments of users with a common demand and set of constraints. The largest segment (54% of the sample) included men and women but was predominantly female: women were 61.4% of this segment. People included in this segment had similar assets: they were likely to be living in households far from water sources and are land constrained. Only 18.3% use purchased charcoal or electricity for cooking. People in this segment were more likely to give importance to the "fast-cooking" bean variety. Segment 2 comprised 46% of the sample, 60% of whom were men. These men and women had more assets and were relatively better-off, as measured by landholding and livestock units. They were likely to use purchased charcoal or electricity for cooking. Each segment had a different cluster of trait preferences and priorities that could be associated with differences in land ownership, wealth, sex, and household size and age. This case illustrates the utility of considering gender differences in the context of a broader social profile. It highlights the importance of going beyond simple comparisons of men and women. With this kind of analysis, breeders can design products for a demographic or market segment of their users, with the knowledge that gender differences have been taken into account.

The components in Figure 2.1 intersect and the arrows signal that a change in one component will produce a change in the others. These causal relationships between the components and trait preferences are not always self-evident. Therefore, tracing out the causal pathway between these different components of gender analysis can throw unexpected light on differences in trait preferences. For example, the often-observed priority given to early-maturing varieties, especially by women and food-insecure producers, may seem contradictory, since earliness involves sacrificing yield (and therefore more food). However, women and the poor are typically land scarce and cash poor (the asset component in Figure 2.1) and face food insecurity; they are trying to meet household subsistence food needs year-round (the market component in Figure 2.1). Early-maturing varieties are one way to manage the asset scarcity (land and income) that exacerbates the risk of food insecurity early in the growing season. On the other hand, dependence on rain, vulnerability to climatic risks, availability of labor, and priorities in time allocation in the face of other household responsibilities may also be factors that influence the preference for earliness. Each of these factors may affect women differently from men. Going beyond the trait preferences and into the causal pathways can help breeders design breeding products that more effectively address the needs of the target population.

Gender inequalities in access to information can be powerful determinants of demand (Katungi et al. 2008). When women and men have different knowledge about plants or animals, they often value traits differently, or value the same ones for different reasons. In the *Oilili Tanzania* case study, women and men respondents had similar knowledge of forage plants and shared many trait preferences, yet valued a given trait in different plants. They consequently ranked the plants differently in terms of importance. In the *Maize China* case study, women demonstrated unique knowledge of maize varieties that enhanced their conservation and dissemination.

Institutions provide the structure of rules and roles underlying trait preferences and adoption decisions. Examples include norms and family arrangements that restrict women from selling grain, leaving the home to go to market, or dictate that women care for livestock but do not own them. Some evidence suggests there may be pervasive gender differences in the prices received by men and women for the same farm output, across many types of farm enterprise and culture (Hill and Vigneri 2011). Women may receive lower prices for selling more of their produce at the farm gate if their time or mobility is limited or because they sell a small volume. Where the family institution dictates women are primarily responsible for household food preparation, they express interest in traits that relate to this responsibility. They will be interested in cooking time, the taste and texture of one variety over another, the amount of water required to process and cook a variety, and so on. If they must peel a tuber before cooking, they will be interested in tubers that are easier and faster to peel. Such gender differences are conditioned by the market. For example, if men produce and sell a crop like cassava to women with responsibilities for processing, the producers usually know about women's preferences with respect to processing traits. If cultural norms dictate that men, on the other hand, are solely responsible for the sale of grain or all the commercial crops, they will be highly interested in yield and traits associated with marketability and price. This dynamic is seen in the *Matooke Uganda* case study, where women panelists involved in the sensory evaluations captured attributes like ease of peeling, color changes, and stickiness of the sap after peeling, related to their institutionalized household responsibilities.

Gender inequalities are embodied in a vast array of state policies that affect how markets work. For example, adoption of new varieties can have a gender imbalance if policy supports centralized, commercial seed distribution systems, more accessible to male producers, and does not support farmer-seed systems on which women producers depend (World Bank 2014). Similarly, a varietal release committee can set standards for varietal release that are exclusionary, as for example, when a variety supplies a product important for women but fails to meet established yield thresholds and so is never released to farmers. The case studies provide examples of how breeding programs can revise their internal policies, strategies, and standards to increase gender responsiveness, such as the changes made in procedures to evaluate varieties and include culinary tests by sorghum breeding in Mali. For a breeding program aiming at improving its gender-responsive impact, some of the most important policies that need gender analysis can be internal standards. For example, the way "farmers" are identified and counted that can lead to exclusion (Twyman et al. 2015). These internal program policies and standards can have the impact of unintentionally reinforcing gender inequalities: as when more weight is given to commercial crops or large livestock, or to size of area planted or size of the herd when a program's strategic breeding goals are defined. For example, when area planted is used to determine what types of beans and bean-growing environments to prioritize for breeding: if the largest number of hectares takes priority, that means larger scale growing environments and commercial bush bean types tend to be prioritized over tiny, back-garden environments where bush beans are seldom grown and intermediate or climbing types are preferred. Since women are more likely to have a substantial interest in and economic dependence on back-garden beans, a gender bias is built into this decision. When gender analysis is applied to understand the social constraints underlying different demand for traits expressed by men and women, it can also shed light on the way gender differences will play out in the subsequent impact of breeding products.

Strategic goals set by a breeding program will affect how it approaches different types of demand from users and its eventual impact. One type of demand expressed in a trait preference refers to what gender analysis terms "practical needs" (Moser et al. 1999). Practical gender needs like faster cooking time or easier peeling refer to an immediate necessity that affects how well one executes the tasks that correspond to one's assigned gender role. When a breeding program prioritizes practical needs, it is focused on helping women cope with and adapt to the underlying gender inequality conveyed in the trait preference. For example, in the *Participatory Sorghum Breeding Mali* case study, the program accepted that they cannot change the gender norms that govern how land is allocated or land rights, and so concentrated on making the best of a bad deal, by trying to improve varietal performance on women's infertile land.

Another type of demand embodied in trait preferences refers to what gender analysis calls "strategic need" (Moser 1999). An example of a strategic need is more egalitarian access to a market chain that challenges the status quo and can overturn a prevalent gender inequality. When a breeding program responds to a strategic need it focuses on the goal of helping women overcome the underlying gender inequality. For example, if women want to break out of home gardening for subsistence, developing less-perishable varieties and a marketable surplus can help meet this strategic need. Women often express a preference for specific crops, varieties, or animal breeds because these have traits that satisfy women's practical needs. These preferences may weigh against a woman producer's decision to innovate to meet a strategic need (Hill and Vigneri 2011). For instance, women tend to favor varieties, crops, or breeds that require less upfront investment and use less purchased inputs. Frequently, breeding on its own has great difficulty in meeting strategic needs and needs to partner with other interventions that have the goal of transforming the underlying gender inequality. An example would be the dissemination of new, fertilizer-responsive varieties combined with fertilizer credit from a partner institution (Karamba and Winters 2015). Programs may expect a greater impact on reducing the gender gap if they chose an approach that addresses a strategic need and takes advantage of synergies among productive factors, such as seeds, fertilizer, and labor (World Bank and ONE Campaign 2014). The important point here is that to be gender responsive, a breeding program may need to define promising breeding products in tandem with a development partner. Planning together when breeding products are designed can throw light on how a development intervention can influence gender equality and enable a technical breeding intervention to realize its potential benefits for women and men alike.

A third type of demand is latent demand. It may be conveyed by women producers in forward-looking participatory breeding, but is usually difficult to detect in data on current trait preferences. Latent demand refers to an unsatisfied need that typically will not find expression when farmers are asked to list their trait preferences but that might be met by invention of a new product. When a breeding program wants to develop completely new products that are gender responsive, it is extremely important to have a solid understanding of the asset and market inequalities that are holding back expression of a latent need, that will very likely also be a strategic need. The *Barley Syria* case study is an example of a breeding program that decided to do participatory diagnosis early in the design of new breeding products, to focus on strategic needs of women for income-generating opportunities and then co-develop new varieties with women producers to expand their participation in seed marketing.

Another way in which the internal policy of a breeding program will set a significant direction for gender responsiveness is through decisions about methodology. A breeding program can have a positive impact on empowerment and gender equality through the way the breeding process is conducted as well as through its final products (Galiè et al. 2017). Some of the case studies illustrate how empowerment results from the choice of a participatory approach to diagnostic studies or field testing that actively engages women as well as men, and triggers change in norms and institutions involved with managing the crop or animal in question. The *Oilili Tanzania* case study demonstrates an empowering approach. Freeing up women’s time spent in fuel collection and food preparation with a faster cooking variety may have an empowering effect if drudgery is alleviated. In sorghum breeding in Mali, women with expertise in observing grain quality are now invited to the research station to score grain qualities of early generation material during the selection process. Women’s participation in trials led to the inclusion of selection criteria that ensure that newly bred varieties have desirable grain quality.

Conclusion: Relevance, Adoption, and Impact

Gender analysis is vital for breeding programs to make sense of gender-differentiated trait preferences, for setting the direction of eventual impact on gender equality and for making decisions about which segments of a broadly defined user population—notably its women producers—merit change in prevalent breeding strategies. Putting into practice the four principles for gender responsiveness summarized in Box 1.1 requires this understanding. The relevance of new breeding products to expressed or latent demand requires analysis of how differences in assets, information, market participation, and risks facing men and women producers affect their preferences and feed into their adoption decisions. On a broad canvas, policies and institutions, including the internal workings of the breeding program, will condition how gender inequality plays out in terms of eventual impact on the different people the program expects to use its new varieties or animal breeds. This context will be helpful for distilling useful lessons and approaches from the case studies that follow.

Key messages of this chapter:

- The golden rule for making sense out of gender-differentiated trait preferences is to look for the explanation of how these preferences reflect underlying gender differences in assets, markets, information, and risk, and the ways institutions and policies condition these. In other words, analysis is needed to interpret gender-differentiated trait preferences.
- Gender-differentiated traits often cannot be interpreted unless they are associated with the picture of assets, resources, and risks provided by the social profile of the customer.
- Not all breeding programs will set out to specifically benefit women farmers; but all programs will make an implicit or explicit decision about whether to do so.
- By understanding how trait preferences are causally linked to social differences, breeders can be better equipped to understand the impact of their work. They can then make decisions in the light of a forward-looking analysis of the potential social impact of a proposed change in plant varieties or animal breeds.

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3. CASE STUDIES

3.1 SETTING BREEDING PRIORITIES

Towards a more gender-responsive bean breeding program: lessons from East Africa

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Introduction

Common bean (*Phaseolus vulgaris* L.) is an important food crop grown and consumed in East and Southern Africa. In East Africa, bean is planted on approximately 1.7m ha of land per year (FAO 2017) primarily in association with other crops, mainly maize, banana, cassava, and other legumes under low input systems (Katungi et al. 2017). It was traditionally a subsistence crop for which women have been considered the primary decisionmakers and contributors to its production (Wortman et al. 1998). Women carry a major responsibility for undertaking a number of activities such as variety selection, weeding, threshing, winnowing, and sorting (Nakazi et al. 2017). They are often responsible for making decisions about the amount of beans to keep for household consumption needs, seed security, and food preparation methods. However, the bean has been moving from being a subsistence to a commercial crop, with men increasingly participating in its production. According to a study conducted in Uganda in 2016, men are involved in nearly all bean production activities, participating intensively in land preparation, fertilizer and pest application, and marketing (ibid.). This transformation takes place in the face of increasing climatic variations and associated abiotic and biotic constraints, making varietal traits for both production and consumption in high demand and critical for development of the subsector.

Bean breeders have been developing varieties with suitable characteristics to meet market and agronomic requirements. Knowledge about traits preferred by end-users is derived from the lessons learned during participatory variety selection (PVS), carried out in the later stages of the breeding process. In sub-Saharan Africa (SSA), PVS in bean improvement programs was started in the late 1990s by the International Center for Tropical Agriculture (CIAT) (Sperling et al. 1993) and became fully integrated within the bean breeding processes in 2000 under the Pan-African Bean Research Alliance (PABRA) model. Since then, PVS has been the entry point for learning about differences between men and women's preferences for bean traits. The near-released germplasm is planted on farmers' fields in multiple locations and evaluated by researchers and men and women farmers at full pod stage (Mukankusi et al. 2015; Amane et al. 2011).

Through PVS processes, breeders have become aware of farmers' preferred bean traits but know little about how much weight is accorded to each trait. Yet, this is important for setting breeding priorities especially when trade-offs between traits are necessary. Cooking time often comes up during discussions with farmers and consumers as important, but breeders had not given it consideration as a priority trait for improvement. As urbanization in SSA grows, such unmet preferences can drive future demand away from bean consumption. Finally, PVS had over the years relied on sex (comparing men vs. women) as the only source of differences in preferences while ignoring other factors such as age and wealth. These weaknesses led to numerous varieties released but few taken up by farmers, which raised questions on how the adoption of improved bean varieties could be enhanced.

In 2012, we decided to employ a choice experiment (CE) method and analyze preferences for bean variety traits in order to understand how farmers value each trait. The CE is a stated preference technique that enables a detailed analysis of the valuation of a good—in our case a bean variety—both in terms of the specific traits that make up the good and their value to different socio-groups. Unlike the PVS technique, which relies on visible traits to analyze preferences, CE is used to identify preferences for both visible and implicit traits of a crop variety, compute trade-offs, and examine the characteristics of the potential users that are more likely to demand the variety.

Our study had two objectives. The first was to use survey techniques and econometric models to assess and compare men and women's preferences for the selected bean traits and estimate implicit weight attached to each trait. The second objective focused on identifying socioeconomic characteristics that influence differences in preferences among bean growers who also are consumers, group men and women producers into homogenous preference segments, and estimate relative segment sizes. After gaining insights from the CE, we explored the potential of including socioeconomic variables in PVS and examine trade-off between traits made by men and women farmers.

Methods

The information used in this case study was gathered under two earlier studies conducted in parts of Kenya and Uganda using different methods. One study collected data through PVS that were conducted on trials established in multiple locations in 2012/2013, where several varieties were planted and evaluated by farmers and researchers in a participatory manner. The second study was a survey of bean-growing households conducted in 2012 using a questionnaire that had several modules, the most important being the module on choice sets. The design of the choice sets and survey implementation are discussed in detail by Katungi et al. (2015) available at: http://academicjournals.org/journal/AJAR. Here we provide a brief summary of the same, followed by an overview of the methods used in PVS in Uganda (also documented in Mukankusi et al. 2015 and available at: www.ccafs.cgiar.org).

Summary of the CE method

The first step in the CE design was to define the proposed bean variety in terms of its attributes and the levels these attributes take. Attributes, hereafter referred to as traits, were **yield, maturing time, tolerance to environmental stresses, taste, cooking time,** and **price.** The selection and inclusion of these traits were guided by experiences from PVS, the production context, and literature (Sperling et al. 1993; Katungi et al. 2017). The first three traits—yield, maturity time, and tolerance to environmental stresses (i.e., drought or diseases)—characterize the relative agronomic advantage of a bean variety and have been a major focus in bean breeding (Beebe et al. 2013). During PVS, farmers usually tell the yielding potential of variety lines by visual inspection on the number of pods per plant. The same approach was used and yield trait (YIELD) defined as high yielding if the variety has many pods (15–20), medium yielding (10–15 pods), and low yielding if it has 10 or fewer pods. This definition of yield was preferred over the standard metric as it is easy for respondents to interpret and can be directly attributed to the variety genetic improvement when other factors are uniform.

The trait tolerance to environmental stress (TORELA) depends on the production location. The level of tolerance of a variety is manifested in its yield potential under conditions of stress. Owing to lack of information on the actual yield of a proposed variety when still under development, it was not possible to express tolerance to environmental stress in terms of absolute yield increase over currently grown ones, the opt-out option. Instead, the trait TORELA was defined in relative terms as a percentage change in yield when there is stress. The percentage change as definition of trait levels was also necessary to accommodate a range of abiotic and biotic stresses across the study sites as well as flexibility in the opt-out option, which is household specific. Then the trait levels for TORELA were defined as: no benefit (0%), meaning that the variety is not tolerant at all compared with the existing varieties; small benefit (30%), meaning the yield loss remains high when stress occurs; and large benefit (50%), interpreted that yield loss due to stress is substantially reduced. The trait of maturing time (MATTIM) captures the number of days a variety takes to complete its growing cycle, from planting through flowering to full maturity ready for harvest in dry form. The levels of this trait were defined as short (60–70 days), medium (75–85 days), and long (85–90 days) (Wangara and Kimani 2007).

How a bean variety tastes depends on the consumer and is thus a subjective property. It was defined in relative terms reflecting a hypothetical situation if it was to change from the status quo to better or worse. This enabled us to estimate how men and women respondents, as consumers, value the taste of beans and its importance in driving adoption of a new variety. Cooking time was defined as the time (in hours) it takes to boil dry bean grain of a proposed variety to the point it is ready to eat. This definition is also subjective, as it depends on the type of cooking fuel and container used, both of which vary across households. For these reasons, the trait was coded in a qualitative way: short (COOKSH) and long (COOKLO). Finally, the hypothetical change in price of seed for a proposed variety was included as a percentage change from the existing price in the community of residence. This was used to estimate the monetary value of each trait included. An a priori expectation here was that farmers would choose to grow a variety if its seed is cheaper, other factors held constant.

For each trait, respective levels were identified in consultation with breeders from CIAT and the Kenya Agricultural and Livestock Research Organisation on the feasibility of achieving the levels and with key informants from farming communities to fit their context. These traits levels were combined into different variety options, each associated with a “monetary price” using computer-aided methods and presented in choice sets. Eighteen efficiently designed choice sets, each containing two bean seed choice alternatives (profiles A and B) and an opt-out alternative (C), resulted from this design. The 18 choice sets were randomly blocked into three versions of 6 choice sets each. To ease the burden on the respondents, each variety profile was presented on a card and included as visual aids during interviews.

CE survey implementation and data analysis

CE and socioeconomic data were gathered through interviews of male and female respondents through a survey of bean-growing households in eastern and western Kenya. The eastern parts of Kenya belong to the drought corridor of East Africa and receive 500–750 mm of highly variable rainfall. Western Kenya is in a high rainfall zone of the country but experiences disease pressure caused by soil-related pathogens. Study sites in western Kenya receive an average of 1,000–1,800 mm of rainfall a year. Two districts were purposively selected from each region to represent each production context; the primary sampling units and households were selected based on stratified random sampling techniques. The number of households per primary sampling unit was fixed at 42 due to budget limitations, and about 14 households were randomly allocated to each choice experimental block. A total of 168 households per district and 502 across the entire sample were surveyed.

Individual interviews were conducted by enumerators who were trained by social scientists and breeders on the purpose of the study and how to administer the CE. Enumerators were also subjected to pretesting to familiarize them with the survey tools as well as to test the suitability of the survey questions and refine them. The pretest was also done to ensure that the CE was fitting and that respondents involved made choices easily. Enumerators were then told to inform each respondent about the context in which choices were to be made before the presentation of the six choice sets. This also involved describing each trait carefully, simply, and thoroughly to each respondent so as to ensure uniform comprehension of the traits and their levels. Each respondent was informed there was no right or wrong answers, and that the interviewers were only interested in his/her opinions.

The descriptive statistics of the socioeconomic variables used in the analysis of the CE data are presented in Table 3.1.1. Generally, women (59%) dominated the sample of respondents who participated in the survey. On average, the number of years of schooling was 9.3, which was slightly higher for men. Men were also generally older than female respondents, but there was no significant difference in terms of household size. In the subsample from Eastern Province, men respondents were more likely than females to be living in wealthier households, as measured by the number of agricultural assets and landholdings.

Table 3.1.1 Mean values and standard deviations of the sampled households, by province and sex of the respondent

	Eastern Province				Western Province			
	Male Respondents		Female Respondents		Male Respondents		Female Respondents	
Characteristic	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Gender household head (1= male, 0 = female)	0.94‡	0.23	0.72	0.45	0.98‡	0.14	0.65	0.48
Number of agricultural assets	21.12‡	12.14	17	7.38	14.34	8.21	13.46	9.64
Village market (1 = yes, 0 = no)	0.78	0.41	0.74	0.44	0.83	0.41	0.73	0.46
Household size	9.07	3.83	9.03	3.99	7.26	4.19	7.12	3.28
Age in years	48.57‡	14.34	44.39	12.8	45.91*	15.14	42.23	15.57
Years of schooling	10.35‡	2.75	8.35	3.62	9.54‡	3.35	7.42	3.55
Distance to water (min)	30.04‡	26.45	23.05	15.32	13.16	14.99	12.25	10.99
Cooking energy (1 = purchase, 0 = no)	0.21†	0.41	0.33	0.47	0.05	0.22	0.03	0.18
Land size (ha)	0.83‡	0.71	0.69	1.03	1.09†	1.16	0.84	0.79

*, †, ‡ = significance level at 10%, 5%, and 1%, respectively. SD = standard deviation.

The CE data were analyzed using random parameter logit (RPL) and the latent class model (LCM). The RPL model, also referred to as mixed logit, can approximate the discrete choice model and was preferred over the standard conditional logit model because it was not affected by independence from irrelevant alternatives assumption. The RPL uses a continuous distribution assumption to incorporate variations in parameters of some traits across respondents. In this particular study, yield, tolerance to environmental stresses, and short cooking time were allowed to vary across respondent. The socioeconomic variables were introduced into the model as interactions with random traits, allowing for convenient interpretations of the resulting coefficients. The analysis was then disaggregated by location (Eastern vs. Western province) because the econometric test confirmed that the two bean production environments were distinct. The full description of the RPL model, and its empirical application, is discussed in Katungi et al. (2015).

The LCM was used to account for differences in demand for traits using implicit segmentation approach. Respondents are assumed to implicitly sort into segments of similar preferences, but their choices from one situation to the next are assumed to be independent. The model also estimates the probability of belonging to a certain segment, which we used to compute segment relative size. Such information on the market size for specific traits is important for making decisions on when and where targeted breeding is economically sensible. In LCM analysis, only the subsample for Eastern Kenya was used.

Summary of PVS-based methods for assessing differences in preferences

After gaining insights from the CE, we explored the potential of including socioeconomic variables in PVS. This was undertaken jointly by social scientists, breeders, community extension workers, and farmer groups in Uganda in 2013. A total of 200–320 farmers (56% women) participated in PVS that were conducted at nine sites of Hoima and Rakai for three seasons. The method used in selecting preferred varieties was a voting system for best and worst preferred variety by every participant. Before actual voting, participants were registered with a few of their socioeconomic characteristics (i.e., landholding, age, and education, soil fertility status of the farm, and bean acreage per season). Each was given a unique number in the register that was also recorded on the voting cards provided to him/her. As usual, men and women voted using distinct colors to enable the team to immediately tally the votes and discuss variety selection criteria by sex.

The vote for each of varieties cast by each participant was coded 1 if the individual voted the variety as his/her best preferred and -1 if the same individual voted it as the worst variety. A code of 0 was assigned to a variety if the individual did not vote that particular variety. This meant that during summing the votes, a code of 0 (i.e., no vote) had no effect on the variety, whereas a -1 reduced the overall preference index of that particular variety. The preference index for each variety was calculated for female participants and male participants and compared for each variety.

Results

Results from the CE are first presented, followed by a discussion of lessons from the PVS for Ugandan sites.

Random parameter logit

Results showed that RPL with random yield, tolerance to environmental stresses, and short cooking time variations fit the data better than the fixed conditional logit model. These results were published in Katungi et al. (2015). All traits included were significantly different from 0, meaning that they influence variety choice. Farmers showed high preference for bean varieties that exhibit a production advantage over their local ones, with better taste and short cooking time. An increase in the levels of tolerance to environmental stresses in bean was valued higher in Eastern Province, where environmental stresses are more severe, than in the western parts of Kenya. Similarly, utility derived from increase in the level of tolerance to environmental stresses was higher among households that operate on smaller farms than those with larger farms due to the risk of starvation when landholding is smaller.

In eastern Kenya, male respondents were more likely to derive higher utility from short cooking time than women, which was surprising and contradicted observations reported from Mozambique (Amane et al. 2011). We consulted with the communities for further interpretation of the results (see responses in Box 3.1.1).

Box 3.1.1. What men and women had to say

One woman said, "There are no longer communal land or bush where firewood for cooking can be gathered for free. We either use charcoal or make fuel wood from trees grown on the farm. Normally trees are planted and controlled by men and cooking is often considered wasting the trees." Where cooking is done by charcoal, men who normally foot the bill for charcoal to cook the beans, may perceive beans that take longer to cook as costly since they use a lot more charcoal. The second explanation was related to the opportunity cost of waiting when bean takes long to cook. This was a response from a man who said that he likes beans which cook faster because he does not have to be held at home because beans are not yet ready. He said, "You know, us men like socializing with our friends out there to get new ideas. We are expected to hang out with friends than being at home."

In western Kenya, both men and women derived the same utility from short-cooking varieties. Difference in preference for short cooking time was influenced by proximity to markets and household size. Both variables were negatively associated with utility from short cooking time. Farmers with better access to markets may have commercial objectives and need varieties with quality traits that are highly demanded in the market by net consumers. Similarly, larger households may attach lower value on short cooking time because of the associated lower per capita cost of cooking when a household is larger.

Farmers were willing to pay a high price for a hypothetical variety with short cooking time and better taste. For example, farmers in eastern Kenya were willing to pay price increases of approximately 47% and 82% for better tasting and short-cooking varieties, respectively. The rejection was even more pronounced in the case of decrease in these traits from the existing levels. Bean producers would require a discount of over 150% and about 50%/kg of seed to accept a new variety that tasted bad or took a long time to cook (compared with the status quo), respectively. Respondents from male- headed households were willing to pay more than were respondents from female-headed households, perhaps reflecting low purchasing capacity among the latter households.

Latent class model

The Akaike Information Criterion and Bayesian Information Criterion recommended by Boxall and Adamowicz (2002) showed that a two-segment model was appropriate for the preferences in the data from Eastern Province Kenya. From the LCM, the probability of belonging to a certain implicit segment was estimated along with the trait utility coefficients, as were socioeconomic characteristics that determine segment membership. The results of LCM are presented in Tables 3.1.2 and 3.1.3.

Table 3.1.2 LCM estimates of bean trait demand in eastern Kenya subsample (SE)

	Multinomial Logit Model		Latent Class Model			
			Segment 1 (54%)		Segment 2 (46%)	
	Coeff.	SE	Coeff.	SE	Coeff.	SE
ASC3	-.385†	0.173	-1.886‡	0.355	.0140‡	0.385
YIELD	.181‡	0.013	.352‡	0.041	.096‡	0.021
MATTIM	-.023‡	0.004	-0.010	0.007	-.0373‡	0.007
TORELA	.043‡	0.003	.0621‡	0.006	.0358‡	0.005
TASTEBETTER	.247‡	0.075	0.217	0.139	.296‡	0.108
TASTEBAD	-.851‡	0.076	-1.039‡	0.143	-.944‡	0.143
COOKSH	.244‡	0.072	.2938†	0.144	.362‡	0.114
COOKLO	-.274‡	0.073	-.3797‡	0.130	-.321‡	0.116
PRICE	-.011‡	0.004	-.0365‡	0.009	0.004	0.007
Individual and household characteristics			**Coeff.**	**SE**		
Constant			-2.869	1.85		
Sex of the respondent			-1.245‡	0.586		
Market in the village			0.541	0.684		
Log of land size			-3.402‡	1.099		
Food security			-0.001	0.003		
Education of respondent			-0.002	0.012		
Log of agricultural assets			1.222†	0.595		
Log of distance to water			0.573*	0.307		
Cooking energy			-1.0503*	0.580		

†, *, ‡ = significance level at 1%, 5%, and 10%, respectively. SE = standard errors.

Results showed that segment 1 consisted of people who derived higher utility from production traits (i.e., yield and tolerance to drought). We call this segment people who preferred bean varieties with relative production advantage over the status quo. On the other hand, people who sorted into segment 2 would like changes in all traits included in the choice sets as implied by the significance of all the coefficients (Table 3.1.2) and were indifferent to changes in price of improved seed. We call this group of people who preferred quality traits because they derived higher utility from traits such as taste and cooking time compared with the utility they derive from production traits. This segment chose the new variety over the status quo and would be the early adopters.

To understand the actual characteristics of each segment, the probabilities computed from LCM were used to place each respondent to a given segment. A respondent was considered to belong to a given segment if he/she had the highest probability for being in that segment. Once placed in a segment, the implicit features of the respondent were matched with observed responses. Characteristics of segments are reported in Table 3.1.3.

Segment 1 was the largest in size, accounting for approximately 54% of the sample. Members in this segment were likely to be living in households far from water sources and are land constrained. They were sensitive to price, which might constrain adoption when their preferred variety is presented at a higher price. Female respondents dominated this segment, accounting for 61.4% of members. Only 18.3% use purchased charcoal or electricity for cooking.

Segment 2 comprised 46% of the sample, 60% of whom were men. These people were living in relatively wealthy households as measured by landholding and livestock units. They were likely to use purchased charcoal or electricity for cooking. Members of this segment show greatest potential as adopters of the improved variety and would not be deterred by higher price of seed relative to the status quo.

Table 3.1.3 Descriptive statistics of characteristics of each segment

Characteristics	Segment			
	Segment 1 (54%)		Segment 2 (46%)	
	Mean	SD	Mean	SD
Respondent age (years)	45.10	13.17	48.46	14.00
Respondent education (years of schooling)	9.26	3.29	9.35	3.46
Household size	9.04	3.74	9.02	4.03
Household head age	51.83	12.33	55.73	12.54
Livestock units	3.98	3.79	4.78	4.29
Land size (ha)	0.47	0.36	1.09	1.17
Distance from water source (km)	31.22	23.11	20.42	17.93
Number of agricultural equipment	20.24	11.85	17.41	7.53
Sex of the respondent (%)				
Female	61.4		40	
Male	38.6		60	
Market in the village (1 = yes, 0 = no)	75.2		75.7	
Households that are food secure (%)	22.7		26.3	
Occupation of the respondent (%)				
Farming	85.38		85.22	
Off-farm employment	9.23		9.57	
Others	5.39		5.25	
Cooking energy (1 = purchased) %	18.30		36.50	

Differences in variety preferences through PVS

This section presents lessons from the study of differences in variety selection using PVS approach. The results of the PVS disaggregated by sex (men vs. women) as commonly done were presented in Mukankusi et al. (2015) and available at www.ccafs.cgiar.org. From this PVS study, researchers measured yield of each variety and found Masindi yellow, followed by NABE15 and KATX56 to have performed relatively well under climatic variations, whereas KATB1 performed poorly (Table 3.1.4). In general, men were more likely to trade off tolerance to climatic variations with marketability and select a highly marketable variety (NABE15), even when its yield was not the best. On the contrary, women put more weight on tolerance to climatic variations than marketability when selecting varieties during PVS. Women were less likely to select KATB1 because of its poor productivity, despite its excellent market traits.

To assess differences within each sex group, the socioeconomic characteristics of each participant recorded during registration were correlated with his/her choices of variety. Results from partial correlation disaggregated by sex are reported in Table 3.1.4 and show that there were variations among women in their trade-offs. For example, younger women were more likely than older women to trade off tolerance to climatic variations with marketability and select a marketable variety (NABE15) that was susceptible to stresses (Table 3.1.4).

Table 3.1.4 Partial correlation of socioeconomic characteristics with the variety selection

Variable	NABE15	Masindi Yellow	Katx56^{NB}	KATB1^{NB}
Researchers Assessed Yield (kg/ha)	***577.1***	***708.7***	***568.3***	***393.3***
	Pooled Sample			
Number of household members	0.4052‡	-0.0445	-0.2175	-0.0666
Years of formal education	0.0953	0.1353	-0.3427	0.0775
Dummy = 1 soil fertility average	0.1164	0.2126†	0.1035	-0.4936‡
Dummy = 1 if soil fertility rate poor	-0.186	0.2314†	0.0189	-0.5267‡
Area allocated to bean (ha)	0.1715	0.0018	0.2517*	-0.1721
Age of participant	0.2835*	0.0268	0.0882	-0.0085
	Women			
Number of household members	0.4377*	0.1127	-0.1489	-0.1227
Years of formal education	-0.1819	0.252*	-0.0556	0.1059
Dummy = 1 soil fertility average	-0.0809	0.364†	0.3503†	-0.3968‡
Dummy = 1 if soil fertility rate poor	-0.2133	0.2761‡	0.1612	-0.4884‡
Area allocated to bean (ha)	0.127	-0.0855	0.2167	-0.0131
Age of participant	0.5388†	-0.0014	0.1092	-0.1071
District (1 = Hoima)	-0.3349	-0.1299	-0.2269	-0.4874‡
	Men			
Number of household members	0.1289	-0.3951†	-	-
Years of formal education	0.0675	-0.2486	-	-
Dummy = 1 soil fertility average	0.0947	-0.3135*	-	-
Dummy = 1 if soil fertility rate poor	0.1039	0.209	-	-
Area allocated to bean (ha)	0.293	-0.056	-	-
Age of participant	-0.1403	-0.4275	-	-
District (1 = Hoima)	-0.3092	0.4661‡	-	-

NOTE: Correlations not computed for men because of insufficient observations.
*, †, ‡ = significance level at 10%, 5% and 1%, respectively.

Conclusions

The CE method used in this study is a good example of a bottom-up approach for generating information about farmers' preferences for variety traits to inform decisions on setting breeding priorities. Results brought to light important sources of differences among bean producers in general and those between men and women. For example, results from the CE method revealed that farmers' preferences for bean traits are influenced by landholding size, age, household size, sex, and to some extent wealth of the household. These factors also are known to be important as determinants of agricultural technology adoption (Feder et al. 1985). By understanding which socioeconomic characteristics that are likely to influence preferences for which traits, breeders can define their target groups and set priorities that respond to the demand. Considering users within population segments framework is useful for designing gender-responsive breeding programs. Time and money can be saved if the users are defined early and their interests and welfare built into setting breeding priorities. With information on demand for individual traits and its determinants, breeders can also anticipate and consider what is changing when they prioritize their breeding objectives.

Results from the LCM indicated that the differences between men and women's preferences are not sufficiently clear cut to support the labeling of any trait as a man or woman's trait. Both men and women may prefer the same traits but with varying intensities, depending on the context. Generally, results show that there is a sizeable demand for the proposed new bean variety with desirable quality traits such as short cooking time and taste in the study area; adoption of such a variety is, however, likely to be constrained if the price of variety seed also increases. Women constitute the biggest proportion of the group that are likely to be constrained when the seed of a new proposed variety is sold at an increased price.

The result that men and women derive significant utility from beans that take a short time to cook reflects the high cost of firewood or charcoal for boiling dry beans, especially now that population pressure has grown and firewood is no longer freely available to community members. Moreover, increasing urbanization is fueling the demand for more convenient foods so as to allow for more time to participate in other economic and social activities. That these dynamics are more pressing for men than women make the short cooking time trait more attractive to men than to women.

Although it was always known that men and women differ in the way they trade off between traits, little had been done to assess differences within sex groups. From the PVS pilot study, we learned that there are significant variations in preferences between older and younger women. This reflects the fact that the production context has changed from pure subsistence to semi-subsistence—thus preferences of women farmers who pursue different objectives are likely to diverge. In the case we studied, older women were more likely to select a highly marketable variety than were younger women. Gender-based barriers to women's participation might constrain younger women more than they do older women, making the latter more market oriented in their bean production.

Recommendations

The result that men value short-cooking beans more than women was surprising because during discussions with men and women groups after PVS, the issues of long cooking time for beans always come from women groups and barely from men groups. The question then is, if men value this trait, why do they not raise it during interface with researchers? One hypothesis is that there could be gender-based barriers that hinder men from fully expressing their preferences during PVS. For instance, some men may not speak up about their preferences for short-cooking varieties for fear that the peers will interpret them as the ones who cook at home and are therefore inferior to their wives. Future research could seek to explore and identify gender-based barriers that may hinder men or women from publically expressing all their preferences for bean variety traits.

The study also showed that in the context of semi-subsistence, gender-differentiated preferences can be blurred and often hard to detect with PVS tools as currently designed and implemented in bean- breeding programs. Therefore, there is a need to adapt PVS approaches to be able to identify and integrate less visible gender-based differences, where gender is defined to include sex, age, and wealth subgroups. The pilot study of assessing sources of differences in preferences through PVS in Uganda is a step toward understanding priorities of farmers facing different constraints and opportunities. Future research should explore alternative ways of adapting the current PVS process to allow breeders to capture differences that may emerge within each gender group, especially as they are faced with the challenges of climate change and growing crop commercialization.

Finally, lessons learned during design, implementation, and analysis suggest that the CE method is skill based. Most national programs face the challenges of maintaining social scientists because this component of research tends to be underfunded. This means that there is a need to invest in capacity building for social sciences within national research systems to support the initiatives for strengthening breeding programs in Africa. When such analysis is based on large datasets that are well representative of the target population, it can unmask the necessary triggers to facilitate variety adoption. Second, the success of gender mainstreaming requires political support, which in turn can be gained through effective communication of evidence-based findings. It is therefore necessary to put resources aside for ensuring that there is always effective communication that will help to generate such a political environment within institutions.

Implications for Breeding

The findings that respondents attach substantial weights to both short cooking time and better taste allude to the need for breeding varieties that have improvements in such variety quality traits. The study has raised awareness among breeders on the strategic importance of these quality traits in driving adoption if considered in breeding. And while previous breeding priority-setting focused on including cooking time and taste as “must-haves” to, say, “do no harm,” now breeders have invested in screening for short cooking time during the early breeding stages. A number of national programs have acquired Matson cookers to preselect for this trait before materials are taken for on-farm evaluation. During PVS, cooking time as well as sensory tests are conducted with farmers and are considered as part of the criteria for selection of potential varieties for release.

Furthermore, bean-breeding programs are now organizing their work under the theme “market-led breeding.” This means that the traditional resilience and productivity traits are crosscutting as breeding targets to identify and add new traits that respond to market demand. Discussions are underway to invest in breeding for beans that taste better and have reduced cooking time. Economists have been asked to perform an ex-ante impact assessment of breeding for quality traits that include the latter.

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A case study of cassava trait preferences of men and women farmers in Nigeria: Implications for gender-responsive cassava variety development

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Introduction

Cassava (*Manihot esculenta* Crantz) is an important staple that serves diverse users and plays significant roles in the livelihoods of smallholder farmers in Nigeria. Cassava's major role as a food source connects individuals and households from different social sections and regions in Nigeria. Cassava storage roots, and edible leaves of some varieties, provide an efficient source of carbohydrate and vitamins when consumed. Its utilization as raw material for food and industrial products provides important income generation for both producers and processors and provides revenue for the nation through local and international markets.

Motivation to be Gender Responsive

By ignoring gender inequities, many agricultural development projects fail to achieve their objective (Gates 2014). This asks for gender-responsive studies to understand farmers' and processors' preferred traits for important crops like cassava and inform breeding initiatives/projects for equitable adoption of technologies by users. Recent studies on some aspects of the cassava value chain in Nigeria, such as cassava breeding and agronomy (Maroya et al. 2011; Akoroda 1995); the adoption of improved cassava varieties (Awotide et al. 2015; Abdoulaye et al. 2013); and cassava processing, postharvest handling, and storage (Uchechukwu-Agua et al. 2015), did not consider the influence of gender roles evident within cassava production, processing, and marketing activities. Cassava processing in Nigeria is mainly done by women, for whom it is an important way to add value, whereas its production is done by men and women (Curran and Cook 2009; Walker 2014). Although men dominate activities like land-clearing and soil tillage, women tend to dominate farm maintenance and food-processing activities. Women dominate (75%) the food-processing and marketing sectors; men dominate (95%) the commercial sale of cassava stems (Ilona et al. 2017). Gender roles along the cassava value chain may determine varying preferences of different groups of cassava producers and processors. For an equitable uptake of improved cassava varieties, gender issues shaping specialized roles of men and women along the cassava value chain across regions in Nigeria need to be identified and examined to inform breeding activities for gender-responsive new varieties. Studies on sex-disaggregated farmers' preferences for the crop's varietal traits and gender-based constraints are now gaining approval and are therefore important in informing breeding priorities as well as seed dissemination and delivery strategies (Teeken et al. forthcoming; Ezeibe et al. 2015; Acheampong 2015; Addison et al. 2014). All these aspects together motivated this study to take gender as an important point of departure and to determine where in the breeding cycle (see Figure 1.1 in Introduction) such gender aspects have possible implications.

Background

In 2015 a cassava-monitoring survey was undertaken to study the adoption of improved cassava varieties by farmers, the cassava seed system, and the variety preferences of men and women in Nigeria. This survey was combined with cassava leaf sampling using DNA fingerprinting to triangulate variety information given by cassava farmers and their spouses (Wossen et al. 2017). This study was followed up with a more qualitative study (Bentley et al. 2017) focused on cassava variety preferences of men and women. The present case study focuses mainly on the findings of the latter study.

In Nigeria, cassava producers and processors show varying preferences for production characteristics, processing needs, marketing demands, and health/nutrient requirements. They basically cultivate, add value, and sell and consume the crop, representing diverse trait preferences and needs. The varied nature of these cassava producers and processors may be based on their experiences and factors such as environment/location, beliefs, age, education, ethnicity, and marital status; all can potentially have an impact on how differently men and women may relate to the crop. This implies the need to breed for different sets of traits in cassava to meet diverse end-uses and end-users. Teeken et al. (forthcoming) asserted that the main preferences of men and women cassava farmers are similar but specific task-related preferences can be distinguished (e.g., women mention relatively more processing-related traits while men mention more agronomy-related traits). This finding suggests the need to investigate processing and food product quality traits, and a closer examination of how gender role specialization influences or shapes varietal choices for adoption and utilization will add to existing knowledge.

The rationale of this study therefore was to inform cassava-breeding objectives to meet the diverse needs of producers and processors, with an emphasis on identifying and responding to the processing- and product-related preferences of women farmers, processors, and marketers.

Methods

Sampling involved a random selection of 20 major cassava-producing communities: 5 each in the southwest, north, south–south, and southeast. Data were collected in 2016 through sex-disaggregated focus group discussions (FGDs), open-ended discussions, and transect walks in the selected communities. A discussion guide for village-level FGDs was developed, covering areas such as varieties grown in the village, trait preferences and why they are important, constraints encountered, and access to seed. Researchers visited cassava fields for clarification and to observe processing activities and have on-the-job discussion with processors. At the end of each day, team members would share their findings, discuss the results, and make constructive criticism. This helped to ensure that findings were consistently in parallel format for women and men.

The FGD team (two men and two women) consisted of social and biophysical scientists with diverse academic backgrounds, namely an agricultural economist, an extensionist, an anthropologist, and an agronomist with experience with research activities in breeding. They were supported by the village-based extension officers and the farmers' leader of cassava growers in each community who provided consent and assistance for proper engagement. In each community, the team conducted separate interviews with adult and young men and women; 40 FGDs were held. An important component of the study was to make sure that women FGDs were facilitated by women. The aim was to ensure probing of relevant gender issues and to make sure that women were not restricted from voicing their opinions. Important aspects of the study were ranking of varieties as well as men- and women- preferred traits within the four regions.

In the southwest all interviews were held in the Yoruba language, whereas in the southeast the respondents were interviewed in Igbo. Other interviews were held in English (or in Nigerian Creole). Notes taken and voice recordings during FGDs were transcribed verbatim and transcribed responses were content analyzed. Similar patterns of responses from all interviews on preferred traits were coded into major themes such as agronomic, processing, and product and culinary traits. Themes on preferred traits and varieties cultivated were entered into spreadsheets and disaggregated by sex of respondents. Preferred traits and varieties cultivated were analyzed and ranked. Commonly reported views were harmonized into text boxes.

Results

With regard to the breeding cycle, preferences were identified at the social-targeting and demand analysis stage in order to set breeding priorities/objectives. However, as this was also part of an adoption study, gender-differentiated preferences were identified at the seed production and distribution stage as well, because the study encountered improved (formally released) and farmer varieties. At the production stage, both men and women farmers are actively involved in the cultivation of the released and farmer varieties, undertaking various production activities till the period of harvesting. These stages gave individual farmers the opportunity to assess/evaluate improved varieties before making assertions as to whether a variety meets their needs or making adoption and utilization decisions.

Analysis revealed that improved varieties have traits that farmers desire and are gradually squeezing out the local varieties. About 80 local varieties and 25 improved varieties were identified from the study communities. Cassava variety names sometimes referred to a preferred trait of the variety. For instance, 'Idileruwa' and 'Oko-iyawo' depict high-yield, root size, and early-maturing traits. Fewer varieties are named after processing traits such as color and taste (e.g., 'Nwaocha', meaning fine white cassava). Trait types mentioned included agronomic (78%), processing (13%), and product and culinary traits (8%). Improved varieties are becoming the standards because they are early maturing and high yielding. Women and men in all regions generally want varieties with high yield, many/big roots, early maturity, in-ground storability (for at least 2 years), tolerance for poor soils, cattle resistance, and drought-resistant properties (in the north) and that are non-watery. A few traits, however, are optional or variable (e.g., some farmers like cassava with high starch content, some prefer low starch content). A recent region-based survey conducted in 2017 on biofortified cassava corroborated findings on starch content—that is, cassava farmers in Benue (northern central region) prefer biofortified cassava with low starch content, but those in Oyo (southwest) preferred high starch content biofortified cassava (Olaosebikan et al. 2017).

Household-feeding responsibilities (e.g., to cope or survive during a period of food scarcity) as well as seasonal and market demand sometimes call for a variety that is early maturing. It is, however, also important to have cassava all year round, like a bank account from which people can steadily withdraw for food and to make money. There are also some traits that are only required in some varieties, or in some places. For example, some communities prefer shorter varieties that are less likely to topple over in the wind. Other villages are pleased with their tall cassava varieties used for setting boundaries.

In general, some trait preferences described by farmers are easily understood (e.g., high yield) whether targeting women or men in any region. Agronomic traits are in general more important than processing ones. Women demand cassava that is easy to peel, although this need could possibly be met with another research solution—not by plant breeding—as women farmers themselves also indicate that ease of peeling is probably largely related to environmental conditions such as harvesting season. Like the women, the men also mention processing and culinary traits (e.g., "going well in soup").

Gender and ranking of preferred traits

When the respondents were asked in their sex-disaggregated groups what traits they preferred in cassava (not variety by variety), men and women paid attention to agronomic and processing traits. Table 3.1.5 shows that women and men farmers in all regions generally wanted varieties to be high yielding (many and big roots), early maturing (ideally reaching maturity within 6 or 7 months), and capable of being stored underground for a long time (i.e., 1 year or more after maturity). Nigerian cassava farmers may need a mix of early-maturing and late-maturing/durable varieties. Men and women farmers in all regions generally expressed a preference for early-maturing varieties—for men, to make quick cash, and for women, to reduce the number of times that they need to weed. Late-maturing varieties are important for household food security and may serve as collateral for obtaining loans for both men and women. Women farmers know that cassava stored in the ground is their "food bank," and they want varieties that can be harvested in phases, a year or more after they are mature.

Processing traits such as sweet varieties that are low in fiber, low in moisture, easy to peel, and have food color (cream when toasted into *gari* and white when processed into *fufu and Abacha)* are more important to women. In the four regions, the men paid attention to processing traits but ranked them as less important than agronomic traits (e.g., yield). Because women process most of the cassava, they mentioned processing traits (e.g., being easy to peel) more often than the men did. When cassava is difficult to peel, women have less time available for other important tasks and end up cutting off some of the good root with the peel. Being hard to peel not only lowers the efficiency of women's labor but also lowers the crop's economic yield. Women, especially in the southeast region, also appreciated the same agronomic traits of cassava varieties as men (high yielding and early maturing), but these are not as important to women as being easy to peel.

Men farmers have the idea that some processing traits such as color are important. For instance, both white- and yellow-colored roots serve different end-uses, products, and market niches. Unlike men, women are keenly aware of major processing and agronomic traits. White color is preferred for certain recipes like *eba*, *fufu* (or *akpu*), *lafun*, and *Abacha* and for drinkable *gari* (stirred into cold water). In the southeast yellow is the ideal color for *gari* that is mixed with hot water to make *eba* (moldable solid food made from *gari*). Women all ranked highly the processing traits of dewatering fast, being moldable, swelling when mixed with water, and retaining its color through processing. Married men also process occasionally (e.g., when their spouses are resting from childbirth). Some men are familiar with processing work, because in their teenage years some helped their mothers make *gari* and *fufu.* Men sometimes operate the mechanized presses and graters, for other households, for a small fee.

Table 3.1.5 Cassava traits preferences by women and men in Nigeria

Regions	Women	Men
Southwest	Easy to peel (1st) Other processing (e.g., makes good *gari*) (2nd) High yielding (3rd) Early maturing (4th)	High yielding (1st) Early maturing (2nd) Stores well underground (3rd) Controls weeds (4th) Ready market
North	Easy to peel (1st) High yielding (2nd) Nontoxic (3rd) Stores well underground (4th) Other processing (e.g., makes good *gari*) (5th)	Early maturing (1st) Insect resistant (2nd) High yielding (3rd) Access to market (4th)
South–south	Easy to peel (1st) High yielding (2nd) Stores well underground (3rd) Other processing (e.g., makes good *gari*) (4th)	High yielding (1st) Stores well underground (2nd) Tolerates poor soils (3rd) Early maturing (4th)
Southeast	Early maturing (1st) Easy to peel (2nd) Stores well underground (3rd) Big roots (high yielding) (4th)	Early maturing (1st) High yielding (2nd) Less starch (3rd) Drought resistant (4th)

Gender differences

Gender difference in preferred traits was ease of peeling for women in all four regions. In two regions (southwest and north) men emphasized the need for more access to markets for cassava roots. In these two regions cassava is a main cash crop, contrary to the south–south and southeast, where oil palm and other tree crops are the main cash crops and cassava is mainly a food crop. Women in all the study regions, however, did not express such need for markets for raw roots. For the women, cassava must undergo value addition to make *gari*, *fufu*, *lafun*, and other food products for which there are ready markets in both rural and urban communities.

Women already have a thriving market for their cassava products. If we had interviewed men and women together, the women would not have bothered to contradict the men, when they asked for better markets for cassava. The women did not ask for a ready market for cassava, because they already have one. We understood that when people say they want "ready markets" they mean something like a higher market price and a profitable or stronger demand for their fresh roots. If the men were to find a more profitable market for their fresh cassava, it might deprive the women of one of the opportunities they have to make money. Men and women may even have conflicting interests. Higher prices for raw roots might benefit men but could even harm women, who buy the roots as raw material to make *gari*, *fufu*, and *abacha*. During this study men indicated that they lacked markets to sell fresh roots, whereas women did not mention this for their processed food products. So what women do not say can be as important as what they do say (Bentley 2016).

Men and women access seed differently. Women farmers' access to planting material is important as most of them cultivate smaller portions of land compared with men, who have better access to planting material and inherit larger portions of land. The women explained that since they grow less cassava than the men (and process more), they are likely to run out of stems sooner. The men can leave a part of their field unharvested, saving the stems for planting time. The women may not always be able to do so, but they can "buy a cassava farm," meaning that they buy the standing crop in the field, harvest it for the roots, but also keep the stems. The women said, "It's our trick." The men may not even realize that they are selling seed when the women buy the standing crop.

Complete data

A complete overview of the tables with data can be found in the full report of the research: http://www.iita.org/wp-content/uploads/2017/Cassava_farmers_preferences_monograph.pdf

Conclusion

Women and men farmers in all regions may be looking for a "basket" of cassava types. For example, most varieties should be early maturing, but there may be a demand for some later maturing varieties, especially if they store well in the soil for 2 years or more. Both genders in all regions expressed a demand for non-bitter (poundable) cassava, but some communities (in all regions) are under pressure from Fulani cattle and might also want some bitter varieties that cattle will not eat. Processing traits such as sweet varieties that are low in fiber, low in moisture, and easy to peel and have the desired food color (cream when toasted into *gari* and white when processed into *fufu* and *Abacha*) are more important to women. Women and men farmers in all regions want some varieties that are high in starch and some that are low in starch. Varieties with yellow roots may find a place alongside white ones. In other words, demands for some different traits may not be contradictory but complementary, because a household or a community needs some different types of cassava.

The overall similarity between cassava traits as expressed by women and men in this study suggests little or no competition between the gender-based tasks with regards to preference traits. Having mechanical peelers could reduce drudgery and time which women can use within cassava production system and/or to better market their food products. Genome-assisted breeding methods with markers linked to cassava outer-skin thickness and adhesiveness to the inner flesh can assist selection in the development of new varieties for gender-responsive breeding. Culinary and processing traits, such as moldability or good to make *gari*, need to be brought up to a more measurable definition if these traits are to be more actively taken up within breeding. However, more specific information on the positionality, future outlook, and possibilities of specific groups of women farmers and processors is needed to further specify their possibilities, needs, and preferences with regards to the different food products that they make.

Implications for Breeding

This qualitative case study has enlightened researchers' prior knowledge on cassava farmers' traits preferences, thus spotlighting product quality and cooking traits. Drawing lessons from this study conducted in one of the world's largest cassava producing countries, breeders could breed more effectively in line with documented preferences to enable equitable benefits for men and women farmers and processors. For example, women farmers will prefer varieties that are easy to peel in order to save time as well as those with weed-smothering characteristics so that women will not spend much on hired labor or herbicides. This study has been able to inform plant breeders on important new traits such as ease of peeling and weed-smothering, and quality traits such as swellability and "good to make *gari*" that can be considered when setting breeding priorities. From the preferences conveyed by men and women, a composite of key preferences should be realized to gear breeding efforts toward improved varieties that, for example, combine food product/processing quality, are high yielding, can be stored in-ground, are easy to peel, and can compete with weeds, to achieve equitable impacts. Farmers often combine varieties with very different properties (such as early- and late-maturing varieties). The amount of traits that can be bred for simultaneously is limited because of trade-offs and limited financial resources. But breeding can identify popular existing land races that can cover some essential traits (like in-ground storability) while others can be included in the breeding program (such as early maturity or food product quality traits). As such, the composite of necessary traits can be divided between existing material and improved material in order to derive a set of varieties that addresses more traits simultaneously.

Research activities using triangulation methods are now ongoing to get specific markers that depict ease of peeling and food quality traits like swelling ability in *gari*. Here, the cassava breeding unit now focuses especially on women farmer–processors (responsible for the production of the largest part of food products within Nigeria) and their preferences. They have hands-on experience in cultivation and processing of cassava, and can inform us on how variety is related to product quality. This requires triangulation with biochemical and food science data. Selection and inclusion of food or product quality traits markers in the development of new varieties will likely lead to more rapid uptake and continued use of these varieties when released and disseminated.

This study, together with the Cassava Monitoring Study (Wossen et al. 2017) study and an additional study on variety preferences that focuses on gender norms (Teeken et al. forthcoming), has motivated the cassava breeding unit to integrate social science and food science within its efforts to define additional traits to be bred for in order to increase adoption.

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Gender-responsive forage intensification in the *ololili* system of Tanzania

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Introduction

Forage improvement is one approach used by the Livestock CRP to achieve its goals of improving food security and livelihoods of small-scale livestock producers. Forage improvement can reduce animal feed shortages, which are a main reason for limited milk productivity and food insecurity in most dry areas. Reliable production of milk provides nutritious food directly consumed by the household or, through milk sales, an extra income that can be used to purchase other food. In Tanzania, pastoral rangelands are constrained by inadequate and variable quantity and quality of forage, especially in the dry seasons when livestock are exposed to prolonged and severe feed shortages (Kakengi et al. 2001; Kanuya et al. 2006). Among the Maasai these forage shortages cause household food insecurity for 4 or 5 months of the year when milk often becomes the only food available to feed the family. Tanzanian pastoralists have adapted a number of coping strategies to overcome dry season feed shortages, including use of crop residues from farming areas, traditional forage conservation systems (*ololili*) (Kamwenda 2002), use of leguminous multipurpose tree leaves (Ndemanisho et al. 1998), and seasonal migrating of livestock to better pastures and water. *Ololili* are community grazing reserve areas (less than 1 ha) that are set aside by a family in the rainy season to then be used to feed their livestock during the dry months (Maleko and Koipapi 2015) when men migrate to the steppe for the herds to graze. The men leave a few cows behind (usually the lactating, sick, or injured ones who would not make it for the transhumance) to be fed by the women with the help of girls and boys and, in turn, feed the family by producing milk (Galiè and Lukuyu 2016). Although previous studies on *ololili* have not included a gender dimension, anecdotal evidence indicates that the management of the *ololili* is influenced by gender dynamics given the complementary roles of women, men, girls, and boys in managing the system. And although the effectiveness of *ololili* has been proven over the years, a study by Mwilawa et al. (2008) shows that the forages in *ololili* are of low quality and quantity, especially in the dry season. Therefore, the potential of *ololili* in meeting the animal energy and protein requirements can be enhanced through forage interventions by, for example, introducing improved grass varieties, improved forage management, and feeding strategies (Lukuyu et al. 2015).

The importance of gender considerations in crop improvement programs has been emphasized in numerous studies (Galiè et al. 2017; World Bank et al. 2009). Many have analyzed gendered crop and variety preferences (Almekinders et al. 2014; Paris et al. 2005) and how gender dynamics affect variety adoption (Almekinders and Hardon 2006; Chiwona-Karltun et al. 1998). Others have analyzed the gendered impact of crop interventions on empowerment and equity (Galiè 2013). Although much attention has been dedicated to the gender aspects in crops in general, limited gender analysis has been integrated into the improvement of forage crops and even less so in research on wild plants used as forage. In the case of forage varieties, evidence from Tanzania is that both women and men manage the livestock in most households and contribute to identifying traits used for selection in breeding (Lengisugi 1995). Amri and Kimaro (2010) argue that breeding programs in Tanzania cannot ignore gender dynamics because they affect food security, health, poverty, and agrobiodiversity management. Given the centrality of the *ololili* in guaranteeing food security for Maasai households in the dry months, research on the system and on forage improvement through it needs to include gender considerations. Gender-responsive forage interventions on the *ololili* can increase (1) the effectiveness of technology development (i.e., developing forage crops that respond to the needs of all household members and are therefore more likely to be adopted) and (2) gender equity of development outcomes (i.e., ensuring that the benefits of agricultural research for development, such as through improved technology, reach both women and men farmers) (FAO 2009; Galiè et al. 2017).

Background

The project

This case study shows three phases of a project to implement a gender-responsive forage improvement initiative in the *ololili* system of Tanzania. The three phases comprise (1) a gender study to assess the gender dynamics in the system undertaken in 2015, (2) the implementation of a gender-responsive forage initiative started in 2016, and (3) a gendered assessment of the impact of the initiative (which has been planned but was not undertaken yet). The project was part of the "More milk in Tanzania" (MoreMilkiT) project, led by CGIAR center International Livestock Research Institute (ILRI). MoreMilkiT was implemented between 2011 and 2017 as a collaborative effort of academic and research institutions and with support from Irish Aid. The project aimed to enhance the livelihoods and food security of dairy-dependent smallholder farmers in Tanzania by improving their access to inputs (feed, breeding, animal health) and services (training, credit, insurance) and increasing milk production. The project worked in Morogoro and Tanga regions with around 400 households across a range of livelihood systems, from fully nomadic to fully sedentary—including Maasai communities—and including both extensive precommercial and intensive commercial dairy farms. The project focused on enhancing forage production as one approach to increasing livestock productivity.

Motivation

Forage improvement was a main focus of MoreMilkiT because forage shortages were the main hindrance to improving milk yields in the project sites. *Ololili* were identified as a promising system for forage enhancement, given their cultural compatibility and proven effectiveness. Because no previous studies on *ololili* had included gender analysis, and because gender dynamics seemed to affect *ololili* management, in 2015 a team of plant breeders and gender scientists from ILRI undertook a gender-sensitive qualitative study of the system before embarking on the forage improvement initiative. Gender analysis of *ololili* was considered to help design the initiative in a gender-responsive fashion, thereby increasing its relevance and effectiveness.

Methods for the gender study

One gender scientist with one local facilitator and one transcriber undertook 16 single-sex semi-structured FGDs with 80 male and 88 female respondents selected purposively from five Maasai villages from two districts, Mvomero and Kilosa, in Morogoro region. Single-sex groups were considered necessary (rather than mixed groups) in these communities in order for both women and men to freely participate in the discussions. In most Maasai communities it is inappropriate for women to speak in front of men unless they receive men's approval each time they want to speak. Respondents were selected among MoreMilkiT participants because their household (1) owned a functioning *ololili* (individual *ololili*), (2) owned a functioning *ololili* together with other households (group *ololili*), or (3) used to own an *ololili* that had collapsed and was no longer functioning (collapsed *ololili*). The comparison among these three types of *ololili* provided a richer discussion on gendered constraints faced in *ololili* management and their sustainability. The respondents mostly adopted a hybrid system for cattle management, known as the "base residence–satellite camp" model: they resided in a stable home base for most of the year but, during the dry season, the men and in some cases the whole family migrated in search of pastures and would then return to the home base.

The semi-structured interview questions were developed jointly by a gender specialist and forage scientists. The study focused on understanding the gender roles and dynamics affecting the *ololili* management and effectiveness, the gendered benefits and constraints faced in the system, gendered knowledge and preferences of forage crops, and interest in forage improvement interventions. A second phase was started based on these findings. A gender-responsive forage intervention, designed by ILRI in collaboration with the Tanzania Livestock Research Institute (TALIRI), was initiated in 2016. This second phase built on the first by (1) integrating into the forage improvement intervention the gender-sensitive recommendations that came from the gender study and (2) combining this technical intervention with a "forage champions initiative." This initiative, which will start in 2018, aims to transform some of the social norms behind the disadvantages women were found by the gender study to experience in the system. The third and last phase, which will be implemented in 2018, will assess the impact of the technology intervention on intra-household gender relations and food security. It will also assess the impact of the forage champions initiative on gender relations and women's empowerment. The next section details findings from the gender study undertaken in 2015 and how these were used to design the interventions undertaken in 2016 and 2017. It also presents the next steps that will be undertaken by the project.

Results of the gender study

The findings of the 2015 gender study show that the *ololili* system relies heavily on women's unpaid labor in its management. Men build and restore the fence; women maintain the *ololili*, feed the livestock through it (with help from boys and girls), and feed the family though the livestock during the dry months when the system is in use and men are away. Gender issues in the governance of *ololili* emerged as a key constraint to the sustainability of the system: lack of finances, community power, and gender dynamics were found to hinder the building or restoration of *ololili*, particularly for poorer women and widows. The latter's' limited power and status in the community meant they were less likely to receive approval from the community to claim a piece of land to establish the *ololili*. If they managed to establish one, their power in the community was not sufficient to discourage male livestock keepers from invading their *ololili* and letting their animals eat up the preserved grasses. Limited power and seclusion norms (which refrain them from interacting with unrelated men) prevented the women from confronting the invaders or asking for compensation. Limited control over household money (for married and younger women) and limited availability of money in general (for all poorer *ololili* owners but particularly for widows) did not allow them to rebuild the fence once invaded. These governance constraints, the scientists concluded, needed to be addressed in parallel to any technological intervention to ensure equitable outcomes. In fact, forage intensification in *ololili* with drought-resistant crops could cause more invasions by neighbors stricken by extreme drought. This would mean that, as a result of the intervention, participating farmers (particularly women and widows) who could not defend the *ololili* would lose all their forage and thereby be worse off.

The study also explored the gendered knowledge about local wild plant species used as forage to establish who in the household would be best placed to select forage crops and varieties in a forage improvement program for *ololili*. In each village, knowledge of local forage plants was similar between women and men's groups in terms of the number of plants mentioned; however, each group ranked the importance of these forages differently. Knowledge of plants seemed to be affected mostly by location rather than, say, the gendered activities performed in livestock management. In terms of traits, the women and men mentioned a similar number of traits (26 in total), 11 of which were common to both groups. The three top traits mentioned by both women and men were, in order of importance, drought tolerance, increases milk production, and fattening. The trait *increases milk production*, however, seemed more important for women than for men, given that women control milk in these communities and use it to feed the children and get petty cash. Only women mentioned the traits *provide shade*, *increase animal's appetite*, *available in dense spots*, *eaten by all livestock*, *give smooth feces*, *can be fed when dry*, *also for human nutrition*, *fruits kill all other grasses nearby*, *help with disease prevention*, and *grow fast*. Only men listed the traits *increase the libido of livestock*, *good for human medicinal uses*, *can cause diarrhea*, *germinate easy*, and *bushy*.

The difference in trait preferences seem to reflect in most cases the different tasks performed by women and men in the household. Men are involved in breeding and in procuring animal and human medicines; women are in charge of feeding animals and household members, identifying diseases, and looking after sick animals. Very few commonalities existed across gender and across locations in terms of the traits women and men attributed to a specific plant. In other words, women and men shared many traits they considered important, but rarely did they assign these traits to the same plant. Even when they mentioned the same plants as important, they ranked them differently based on different traits they assigned to them.

Finally, both women and men from all villages expressed an interest in planting forage and dual-purpose crops to better face frequent droughts, weather unpredictability, scarcity of land, and food insecurity. Both male and female respondents showed interest in introducing improved fodder in *ololili*, particularly dual-purpose crops available through MoreMilkiT and not present in the villages. Both believed that better management of the system would also help increase forage production and milk yields, particularly vis-à-vis increasingly frequent droughts. Also, forage intensification through *ololili* was seen as a possible solution to the current conflict over land use between crop and pastoralists. Considering that both women and men were involved in managing the ololili, that they had similar knowledge of plants and complementary trait preferences, and that they had similar interest in enhancing the system through a forage improvement, the scientists concluded that a follow-up forage intervention needed to be gender balanced in terms of participation. Because women and widows in particular seemed to be most disadvantaged in the system, both at household and community levels—while also being in charge of feeding the family in the most difficult months of the year with only the weakest livestock available—it was agreed that the follow-up intervention would need to actively respond to their various constraints.

Methods for the gender-responsive forage initiative implementation

A new phase of the project was then initiated by TALIRI and ILRI in four sites in Kilindi and Handeni districts, Tanga region, in December 2016 that built on the findings from the gender study. The intervention included four activities implemented by two forage experts from TALIRI:

1. Implementation of the gender-sensitive Feed Assessment Tool (FEAST)
2. Training and demonstration days on improved feeding through locally available forage options
3. Development and implementation of a strategy to improve the productivity of ololili through already existing forage plants and newly introduced plants
4. Identification and visibility enhancement of forage champions: one woman and one man who showed the best forage management through *ololili*.

The latter activity, which will be implemented in 2018 and involve a gender scientist, was identified as necessary to transform some of the gender norms that were found to disadvantage women in the system. This transformation would be initiated by increasing community awareness of women's role in *ololili* management, of their knowledge about plants, and of their skills in forage management. We expected this increased visibility to enhance opportunities for women to take part in decision-making related to *ololili* management, and to participate in the intervention. We expected these changes to ultimately enhance women's ability to manage the *ololili*, vis-à-vis other household and community members, thereby also increasing the overall sustainability of the system. In parallel to this intervention a study was planned to understand (1) problems and opportunities in the current feeding practices through FEAST; (2) behavioral changes by cattle keepers/dairy farmers that would result from their participation in cattle-feeding demonstrations; (3) gendered roles in the management of the new forage plants introduced and how these may influence the uptake of the newly introduced plants, and (4) changes in perceptions of women's role in *ololili* management and forage plants. The FEAST assessment took place in 2017, the rest of the study will be undertaken in 2018. The gender-sensitive FEAST was utilized at the outset of phase 2 to identify problems and opportunities in the selected sites in order to better target the forage improvement strategy. Mixed-sex FGDs (rather than single-sex group discussions recommended by the gender-sensitive version of the tool) were conducted.

Results and activities of the gender-responsive forage initiative implementation

FEAST confirmed that no intensification was practiced in the *ololili*, up to that date. It helped plant breeders identify legume and grass species (*Calopogonium mucunoides, Chloris guyana, Centrosema pubescens*, and *Cenchrus ciliaris*) compatible with the existing natural pastures in terms of moisture stress tolerance, other climatic conditions in semi-arid areas, and contribution to the nutritive value of the existing *ololili* forage vegetation. These species addressed two out of the three trait priorities identified during the gender study as common to men and women: *drought tolerance* and *increases milk production*. One of these species, *Cenchrus ciliaris*, was also particularly recommended by farmers in Sindeni following their appreciation of the crop through the demonstration plots established during a previous project focused on forage.

A training was then organized in Handeni and Kilindi districts focused on the following: management of natural pastures, establishment and management of improved pasture and forages, pasture utilization and supplementation of concentrates (feeds and feeding), estimation of forage yield in *ololili*, and estimation of stocking rates and carrying capacity of grazing lands. Demonstrations on improved feeding through locally available forage were also carried out. The training involved 60 men, 23 women, six boys, and five girls. The involvement of women and girls in the training was guaranteed by community leaders who had been sensitized by TALIRI about the importance of a gender-balanced participation for the success of the intervention. As a result of the training, 16 farmers (2 women, 14 men) were identified as interested in the second activity: implementing forage improvement strategies in their *ololili*. Male farmers involved owned *ololili* that ranged in size between 3 and 50 acres. The sizes of the *ololili* owned by the women ranged from 5 to 10 acres. The strategy to improve the productivity of *ololili* comprised three steps. The first step, “selective bush clearing,” involved removing some bushes/plants in grazing land to allow edible understory pasture species (grasses and legumes) to grow in *ololili* grazing land (Figure 3.1.1). The removed bushes/plants were used as fencing material. Women and young girls collected the smaller bushes and plants to be used as fuel for food preparation.

Figure 3.1.1 Part of *ololili* after selective bush clearing, Kilindi District.

“Fence building” was the second step of the strategy. It involved piling up locally available material (i.e., trunks, thorny branches, bushes) around the perimeter of the *ololili* in order to claim the community land as private *ololili* and to prevent livestock from grazing the area in the wet season, thereby allowing the grass to grow and intensify with the rains for use in the dry season. A line of live fencing species (*Agave sisalana* and *Euphobia trucalli*) was also planted to further strengthen the fence—by providing a more permanent barrier than thorny branches or trunks which can be destroyed by ants or get decomposed over time—and discourage invasion (Figure 3.1.2). Fencing involved exclusively men and, in most cases, hired male workers.

Figure 3.1.2 Fencing in one of the *ololili*, Handeni District.

The third step of the strategy involved "over-sowing." Over-sowing is one of the climate-smart practices and involves planting of grass/legume seeds directly into existing vegetation, with minimum tillage strips or without tearing up the vegetation, or the soils. It was an easy way to fill in bare spots in the *ololili* grazing lands which improved the plant density of *ololili*. Over-sowing can be practiced every year in these sites just before the short rains of October–December, and can be repeated during the most reliable rains fall in March–June. All family members were involved in over-sowing (Figures 3.1.3 and 3.1.4).

Figures 3.1.3 and 3.1.4 Over-sowing the *ololili*, Kilindi (*left*) and Handeni (*right*) districts.

In July 2017, a brief assessment of the overall impact of the intervention according to the farmers was conducted by TALIRI. Unfortunately, the information was not disaggregated by gender. The farmers expressed satisfaction with the intensification of the *ololili* vegetation (Figures 3.1.5 and 3.1.6). Although the intervention is just getting started, farmers mentioned their ability to better feed the livestock. They were waiting to assess the potential of the intensified *ololili* at the end of October, when the dry season was at its end and forage grasses were basically not available. Because of increased forage production, most of farmers participating in the project said they are now interested to get crossbred dairy cattle breeds that consume more forage but produce more milk.

Figures 3.1.5 and 3.1.6 Improved *ololili*, Kilindi (*left*) and Handeni (*right*) districts.

Conclusions

This case study presents findings on the gendered labor organization and constraints in the governance of the *ololili* system, and the gendered knowledge of local and wild forage plants and trait preferences. The *ololili* system was found to rely heavily on women's labor when it was in use during the dry season, whereas livestock management involved both women and men. Women and men's groups were found to have similar knowledge of local forage plants but ranked their importance differently. The two groups mentioned mostly similar forage traits that mattered to them but assigned these traits to different plants and ranked the plants differently. The study has also explored respondents' interest in the future of the system through forage intensification. This information starts to fill a gap in the literature about gender considerations in wild plants used for forage in East Africa and in the *ololili* system of Tanzania in particular. Gendered management and knowledge related to *ololili*, livestock, and plants were considered a strong basis to involve both women and men in crop improvement. At the same time, gender norms and dynamics were found to strongly affect the ability of women—mostly poor women and widows in particular—to manage *ololili*. These social constraints in the governance of the *ololili* were found likely to decrease the success a forage technology intervention because they limited the sustainability of the system. This information was therefore used to design a gender-responsive forage improvement intervention that addressed technology improvement, and also started to address gender dynamics and norms. Such a technological and institutional package was considered necessary to enhance both technology effectiveness and gender equity. The forage champions' initiative, which was designed to specifically address gender norms that hinder women's control over *ololili* and its benefits, is the next step of the intervention. In the months to come we will assess its impact on women's visibility as good *ololili* managers and knowledgeable forage growers. We will assess whether this visibility increases women's ability to claim rights to use community land for *ololili*, and defend these rights against invasions by neighbors. Future work also includes an assessment of gendered changes related to the intensification of the *ololili* in intra-household: (1) workload distribution, (2) livestock decision-making, and (3) household food security. More research is needed to assess how strategies to leverage gender norms conducive to gender equity could facilitate the involvement of women in such technology interventions.

Lessons Learned and Recommendations

The gender study presented here shows the usefulness of conducting gender analysis as a basis to design a gender-responsive forage intervention that is more likely to benefit all household members and thereby contribute to both household food security and the gender equity of development outcomes. The forage intervention, in the case of our study, introduced two forage species that reflected two trait preferences common to women and men. The experience with implementation showed the need to purposively include women along with the men at the outset, and the usefulness of involving community leaders to increase a gender balance. Yet the limited involvement of women, despite these efforts, shows that more strategies are needed to ensure that women are able to participate and benefit from technology improvement. This case study also shows that unless gender considerations are integrated in key steps of a forage intervention, gendered information can easily drop out and be overlooked. This was the case of FEAST, which was conducted with mixed groups thereby obscuring gendered forage improvement options, and of the brief impact assessment that was also not disaggregated by gender. Overlooking gender considerations at these key moments has consequences on the ability to integrate gender in follow-up activities such as, for example, planting different crops reflecting gendered needs and preferences, or designing new strategies to address new gendered constraints or opportunities emerging from the intervention.

On these bases this case study recommends involving gender and forage scientists in the key steps of the study, and building the capacity for gender responsiveness of project implementers to ensure that findings from gender analysis are translated into concrete action. This case study also shows how other social categories intersecting gender, such as wealth and social status, need to be considered for a proper assessment of gendered needs, preferences, and opportunities. Finally, the case study shows how undertaking gender analysis resulted in the need to expand the scope of the breeding intervention to address issues of resource governance. This study therefore raises the question of to what extent a technological intervention alone is effective in contexts where institutional constraints hinder the ability of some groups of livestock keepers to utilize and benefit from it. It recommends that breeding interventions be supported by institutional ones, to deliver a technological and institutional innovation package for forage improvement outcomes that are both effective and gender equitable. Teams involving experts from various disciplines are better placed to address this type of complexity and better target both technological and institutional constraints in forage improvement for livestock development.

Implications for Breeding

This case study showed that the women and men respondents held similar knowledge of forage plants, shared many trait preferences but assigned same traits to different plants, and consequently ranked the plants differently in terms of importance. The trait preferences that were different between the two groups related to activities performed by one gender only. We conclude that assessing gendered preferences in wild forage plants is important to introduce forage species that reflect the needs of the whole household and that can be used to prioritize traits in future breeding. Further, the case study recommends that the gender capacity of those implementing a forage improvement intervention be built for these findings to be translated into gender-responsive breeding at community level: findings and recommendations from gender-sensitive analysis are useful to communities only if they are operationalized in a gender-sensitive manner. Finally, we recommend that a breeding program assess the need for an institutional intervention to complement a technological one (i.e., variety development and delivery) to enhance the effectiveness of the latter and progress toward equitable outcomes. Teams composed of scientists from various disciplines (including breeders and gender scientists) are best placed to develop locally relevant forage improvement interventions.

Toolbox

Gender-sensitive FEAST**:**

The women's empowerment in livestock index could be a useful tool to assess how participation in the forage interventions affected the empowerment of women, specifically in relation to livestock-related activities.

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Poultry Trait Preferences and Gender in Ethiopia

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Introduction

Poultry has been described in Ethiopia as "the first and the last resource a poor household owns" (Aklilu et al. 2008, p. 117), meaning both the first step on the livestock ladder, and the only capital that a household has left when it declines into poverty. Poultry has entered the livestock research agenda as a low-cost, low-input source of protein or cash income, and as a means of women's empowerment (Alders and Pym 2009; Guèye 2002; Mack et al. 2005). In this context, although poultry refers to a group of domesticated birds, including chickens, ducks, geese, and quail, since in Ethiopia, chickens are the only birds from this group that are economically significant, and are the focus of this case study, poultry and chickens are used interchangeably. Chickens in Ethiopia also have a richer history of interaction with humans than simply as sources of food. In the case of village chickens. In the case of village chickens, studies carried out by agricultural science researchers have mentioned their use beyond consumption and sale, such as for mystical functions and in social relationships, hospitality, and exchange of gifts for social relationships (Aklilu et al. 2008). These uses are rarely taken into account by interventions that develop and deliver new chicken breeds that generally only focus on productivity-related traits.

The care of poultry is primarily associated with women, as traditional forms of chicken production involve care in the house or backyard, and thus often fall within the sphere of "women's work" (Alders and Pym 2009; Guèye 2005). In addition, women often are responsible for continuing traditions that use poultry, in terms of both consumption and spiritual practices. Ethiopia is an interesting place to study these relationships between members of the household and chickens, due to a high level of indigenous chicken production (Alemu et al. 2008) and an ongoing role chickens play in social relations and religion (Aklilu et al. 2007; Dessie and Ogle 2001). The "village" ("extensive," or "backyard") system, involving minimal inputs for labor, food, or housing, characterizes small-scale chicken production in Ethiopia and remains the focus of development interventions due to its low productivity (Alders et al. 2009; Mack et al. 2005; Sodjinou 2011). Research has rarely taken into account gendered preferences for chickens in the context of the village management system.

The term local (or "indigenous") chickens is used in the literature to describe chickens that can be kept in the free-range scavenging system, although there may not be any specific breed characteristics (Dana et al. 2010a; Halima et al. 2007). The term exotic chickens refers to commercial breeds, which have been introduced since the mid-twentieth century, as part of programs of poultry improvement (Moges et al. 2010a; Wondmeneh et al. 2015). In this context, "improved" breeds refers to local birds that have been put in breeding programs to improve desirable traits such as productivity. "Mixed" chickens are those that have been bred from local and exotic chickens, both unintentionally and intentionally by poultry producers to try to combine desirable traits (e.g., local behavior and exotic productivity) (Ramasawmy, unpublished). This study found that this technical language can at times hinder communication between livestock researchers and farmers.

Poultry research and extension in Ethiopia started in the 1950s, with distribution of exotic breeds to farmers and small-scale commercial poultry producers. Today, poultry technology is part of the extension programs of regional agricultural bureaus, which promote and distribute exotic breeds, with some advice on feeding, watering, housing, and disease control (Teklewold et al. 2006). Chickens form a significant part of the "women's development package" delivered as part of the extension services of the Ministry of Agriculture and Rural Development (Cohen and Lemma 2010), as well as other women-focused programs led by nongovernmental organizations (Woldegies 2014).

Despite this long history of introduction of improved breeds, the most recent statistics suggest exotic and hybrid birds together make up less than 5% of the national poultry flock (CSA 2015), and the majority of exotic poultry is kept on intensive, large-scale commercial poultry production farms (Alemu et al. 2008). A number of issues have been identified that may affect the effective raising of introduced breeds, such as absence of an immunization program to counter reduced disease resistance (Dana et al. 2010b), marketing (Aklilu et al. 2007), lack of credit and extension services (Teklewold et al. 2006), and biosecurity (Alemu et al. 2008; Bush 2006). These issues, and a failure to take into account the context of production (e.g., gendered preferences in chicken production), can lead to farmers, who are acting within local practical and social constraints, not adopting new breeds.

Background

This study was the result of a collaboration between the Arts and Humanities Research Council UK project "Cultural & Scientific Perceptions of Human-Chicken Interactions" and the African Chicken Genetic Gains (ACGG) project. The ensuing "Going Places" project was based on anthropological research by Ramasawmy (unpublished) which examined the relationship between women and chickens in the Amhara region of Ethiopia. (The title comes from an Amharic proverb: "Women and chickens rise early in the morning, but they have nowhere to go.") The aim of the project was to examine the issue of women's socioeconomic immobility, by taking a multidisciplinary approach to gender and chicken husbandry, past and present. This involved bringing together livestock scientists from ACGG, artists and the National Museum of Ethiopia, and a multidisciplinary team from the United Kingdom, which included a museum curator, archaeologists, a geneticist, and an anthropologist.

The ACGG project is led by ILRI and is supported by the Bill and Melinda Gates Foundation. It is a platform for testing, delivering, and continuously improving tropically adapted chickens for productivity growth in SSA. Women and their empowerment are central to ACGG, given women's central role in chicken production in the household. At its onset, the project assessed the traits preferred by female and male smallholder chicken farmers (from more than 3,500 households through a baseline survey). One of the goals of the Going Places project was to expand on the ACGG baseline survey, particularly in relation to trait preferences.

The baseline study by ACGG, where 70% of the respondents were women in the household, identified the desirable traits for chickens: that grow bigger and faster, lay more eggs, and have high survival rate and “good physical appearance.” Physical trait preferences are usually associated with production and productivity; however, previous research by Ramasawmy (unpublished) suggests that good physical appearance can have several meanings, beyond an indicator for suitability for consumption, health, or productivity. The trait can have meaning for the potential use and value of chickens (for spiritual or religious practices, for example).

With respect to cows in Tanzania, Maia Green (2017) suggests that animals are not purely tools or objects, but parts of a network of relationships. This shift toward seeing animals as entities to live with— not just “good to think” or “good to eat” (Kirksey and Helmreich 2010)—has gained popularity in the field of multispecies ethnography. Ethnographic research on animals in Africa has often focused on the link between men and high-status livestock such as cattle, whereas women are linked to low-status chickens, which “garner much less attention, wield little status and power, and feature in low-valued domestic subsistence or impersonal industrial agriculture realms” (Hovorka 2012, p. 875). This focus on species more often controlled by men overlooks women’s experiences of livestock management and preferences for breeds or production systems.

Poultry, however, are generally controlled by women in East Africa. As those responsible for both the care and consumption of poultry, women express stronger preferences than men, in particular for traits that have cultural significance (Ramasawmy, unpublished). Women also are often the targets for development focusing on both interventions in systems of care, and introduction or improvement of breeds. However, previous studies in Ethiopia have noted that although male farmers acknowledged the special knowledge of women in regard to chickens, women’s voices were not often heard by researchers (Aklilu et al. 2008).

Against this backdrop, the present case study examines the following:

- While research often focuses on species that are controlled by men, this study focused on chickens, a species mostly controlled by women in small-scale systems of East Africa.
- Research often focuses on trait preferences of men or assumes productivity-related traits to be priority. This study explores the trait preferences women have for chickens.
- Farmers and researchers use different language to talk about breed characteristics. Male and female farmers also showed differences in how they spoke about chickens. We adopted an anthropological approach to explore local meanings and preferences for breeds to bridge the language gap.

We initially intended to carry out the gender-based research in two regions of Ethiopia; however, the political situation in late 2016 led to a restriction in areas that researchers could travel to and a shortened time allocated for field work. Consequently, the study focused on four ACGG sites in the peri-urban region of Addis Ababa.

By taking an anthropological approach to understanding local preferences and practices around poultry care and use, future interventions can be designed to be more effective. On this basis, Going Places undertook an open (i.e., not limited to a predefined list of traits) and in-depth exploration of gendered trait preferences for chickens in the context of the respondents’ households. The insights provided by this open exploration can be used by the second phase of ACGG, which is setting up the “Long-Term Chicken

Genetic Gains" program for SSA, which aims to produce chicken breeds that are more relevant for the women and their households, providing options for different contexts.

Results

The ACGG baseline

Both male and female participants agreed that the traits identified by the ACGG baseline study were important (fast growth, lay more eggs, high survival rate, good physical appearance). There was a particular focus on disease resistance, due to the high levels of disease and mortality that many participants had experienced in their flocks. Large body size and weight and meat quality were particularly prized in relation to their suitability for consumption. The question of good physical appearance led to some debate. Although men mostly related this trait to health and size, women also considered it in relation to the beauty of chickens and potential use and sales value.

Physical traits

Physical appearance (e.g., color, pattern, and comb) may not necessarily relate to standard favored traits, such as meat quality or quantity. It may, however, be related to perceptions of traits linked to indigenous and introduced breeds (see below). Previous research by Ramasawmy (unpublished) found that preferences for physical appearance in a predominantly Ethiopian Orthodox Christian Amhara region of Ethiopia were strongly linked to the religious and spiritual uses of chickens. In that context, red chickens and double combs were seen as highly desirable, and black chickens and single combs were viewed as highly undesirable, both for sale and consumption. This impacts market price—for example, red and white cockerels with a double (rose) comb have a higher market price than cockerels of the same color and a single comb (Moges et al. 2010b). As the capital (Addis Ababa) is a more culturally heterogeneous location, we might expect this to be different.

It was only some women who identified color as being part of a good physical appearance and an important trait. The colors identified as positive were black and white stripes, and red (including only some red, or red with black dots). White chickens were identified as not being of interest. Double combs were also identified as a positive trait (the Amharic term *dereb*, frequently translated as *double*, also refers to any comb type that is not a single comb, including rose). Some linked the color and comb preferences to local traditions which people no longer followed (although were unable or unwilling to give any more detail). Interestingly, the emergence of a preference for black-and-white striped chickens suggests a growing popularity for *koekoeks,* a South African breed.

Most identified height, weight, and meat quality as being important physical traits in chickens, linked to their use in consumption, as indicators of good health, and potential productivity.

Behavior

Behavior is not often considered in trait preferences for poultry. Yet both positive and negative behavioral traits were frequently brought up during interviews, most often by women (discussed in section 3.6

below). The importance of showing “normal” chicken behavior (e.g., showing a predator response, and laying and brooding eggs appropriately) was often emphasized. Negative behavioral traits were also identified, including higher than usual levels of aggression within flocks (biting and attacking each other). Exotic chickens were described as being particularly difficult to manage without confining them, as they were easily caught by thieves, predators, and people in the area who wished to harm them. Some wondered whether undesirable behavior was linked to the exotic breeds themselves, or the way in which project chicks were hatched and distributed away from adult chickens who might show them proper behavior.

Positive and negative value of traits

Positive traits were linked to use (suitability for consumption, productivity, and marketing) as well as an appreciation of beauty and the emotions they stirred in producers. Negative traits were linked to cost, both in terms of finance and labor, but also the disruptive effect on relationships with their neighbors and their potential for theft and injury.

Local, improved, mixed, and exotic chickens

Using the terms *local*, *exotic*, *improved*, and *mixed* in this type of research is often complex. Although chickens are not native to Africa, they have been present in most places for long enough to be well-adapted to local conditions and tastes (Desta et al. 2013). Researchers and participants may not agree on the meanings of the terms; for example, a researcher might refer to commercial breeds by name and describe hybrid birds from a genetic perspective. But farmers often do not have access to this information when purchasing birds, and identify birds as belonging to these categories by their physical characteristics, taste, or productivity. Farmers may, for example, associate particular colors and patterns, and tasty yellow-yolked eggs with indigenous chickens, and high levels of productivity with foreign breeds, regardless of the actual provenance or breed type. As one woman told us, “We don’t choose between best breeds or not, we just buy it from the market … by guessing.” As men are often likely to be more educated, able to attend extension meetings more regularly, and to have more frequent contact with agricultural agents, there may be a gender component to this information access. This leads to complexity when understanding producers’ preferences for poultry types—namely a desire for disease resistance of the local chicken types, and the high productivity of the exotic birds—as shown by the experiences of these two women:

> The local ones will not be affected by disease and they have less tendency of illness. They can endure many challenges and these [exotic] chickens don’t have strength. That is why we want local chickens.
>
> The exotic ones lay eggs non-stop. The local chickens’ loss exceeds their benefit because they don’t have a good outcome regardless of the expenditure and feed. But you can get good results from the exotic [ones]. …

Gender and relationships with poultry

Although men and women did show similar preferences for physical traits, the reasoning behind these preferences differed. As expected, most traits were linked to consumption and productivity. Male respondents focused on productivity, health, and marketing of chickens. In addition, their interest in poultry was often to scale up to an intensive scale of production, prioritizing productivity and sales value of birds. And while female responders wanted to increase the scale of production, most wanted to keep this at a household level, and thus valued the traits that allowed chickens to be kept in an extensive system while increasing productivity. Part of the reason for this was the increased labor and space required to keep chickens at a commercial scale. In other contexts, as poultry production has become more profitable, men have taken over from women in, for example, Botswana (Hovorka 2006). Although here women did not state this was the case, men were more likely to express an interest in taking a commercial approach.

Women also discussed traits in the context of traditional uses or preferences, regardless of whether they still followed these traditions themselves. In previous research Ramasawmy (unpublished) found that women had the primary responsibility for food preparation, and that *doro wot*, a traditional chicken stew, was a particularly significant dish for women. Men were more likely to distance themselves from religious and spiritual practices involving the sacrifice of chickens, due to social pressures to appear "modern" and "educated."

Women were also more likely to talk about chickens' behavior. These behavioral traits are significant not only in terms of the survival of flocks, but also for their relationships with the chickens. Women were much more likely to positively liken the behavior of their chickens to that of humans:

> The woman gives birth to her children and tries to raise them well and it is the same with the chicken, the hen tries to scavenge and feed the baby birds. She will sacrifice herself for the chickens and protect them from predators. She will feed them by scavenging even when she hasn't eaten. It is the same with women.

Women also emphasized the relationship between themselves and their chickens. This applied to both their personal feelings for chickens, describing as seeing them like children and describing the chickens as returning those feelings for them:

"I looked at them so closely and watched them grow from day to day; I don't even look at my children this close. I used to be delighted when I heard them singing. You watch them with delight when you see them grow up. It is like looking at a child that starts crawling, then standing and so on."

This links to the "living-with" aspects of understanding animals. Although those focused on economic and productive uses of chickens may consider relationships between humans and livestock and household pets to be completely separate, the living-with experience of those who care for the livestock may vary. In the case of village chickens in Ethiopia, where people live closely with and may sleep under the same roof of their chickens, the behavior of these chickens has a considerable impact on their interactions with them and their perception of them as "good." This example shows how those who care for chickens describe them as individuals whose lives intersect with their own:

> When they want to lay eggs, especially one of the chickens comes straight to me and it is me who takes her to the egg laying place. My neighbor says, "here comes your customer carry her to her place." There is also this chicken, when my husband is at home, she gets on the bed he will make the pillows ready for her she lays egg there and leave. She does this every day I think she has taken this as

customary. She will be there on her time. If we are not at home she will run around and lay at her own shelter, but if we are she will come directly to the house.

Conclusions

The study revealed the value assigned by the women respondents to so-called neglected traits (i.e., traits other than yield or meat taste) that breeding programs would usually neglect. Despite the apparent ineffective impact of these traits on, for example, livelihood or nutrition, the study shows that they affect whether a breed may be adopted or not. Similarly, the study showed local cultural traditions associated with chickens that may affect adoption. A breeding program may need to develop chickens at regional level (rather than, say, national level) to include these traits and increase relevance.

The introduction of improved or exotic breeds brings with it a need for increased inputs, including building shelters, combatting higher disease susceptibility, protection from predators, and use of specialized feed. These characteristics have gendered implications when the new chickens are introduced into a household. Some women considered this a reasonable trade-off for the higher productivity of these breeds, whereas others considered it a major barrier, and preferred the low-input production system of local chickens. Women, in fact, have generally less access than men to financial resources needed to purchase animal medicines, building material, or specialized feeds. Their access is even more limited to extension services that provide support on disease management, for example. At the same time, evidence is that when new livestock breeds are introduced, women bear the increase in workload. For these reasons women may be less able or interested in adopting new breeds. However, adoption could increase if these breeds were better adapted to women's needs, or the circumstances under which women raise them changed.

The study shows that some women expressed an interest in the chicken-raising system rather than just traits; they prioritized chickens that can be raised in extensive, low-input farming. This may relate to women's prioritization of breeds that need less input and labor that they otherwise cannot afford. This finding emphasizes the need to adopt a gender approach in ACGG. Gender research often argues for the inclusion of both women and men in livestock research that tends to focus on species that are most important to men (and consequently male trait preferences). ACGG, however, focuses on a species that is generally more important to women than men (as confirmed by this study) and involves more women than men. The authors of this case study believe that a focus on women is justified, given women's interest in chickens as opposed to men's interest in chickens. We also argue that, when developing new breeds, ACGG needs to adopt a gender approach (rather than focusing on women only) in order to appreciate the wider context and gender dynamics behind chicken-rearing in the household.

An issue raised by this study is the potential of providing pathways out of poverty through small-scale women farmers—often the most destitute—and chickens, among the less lucrative species along the livestock ladder. Given that the goal of ACGG is to enhance rural livelihoods, we argue that women and chickens are an appropriate focus for ACGG, particularly if it supports more broadly women's ability to engage in the poultry sector by, for example, supporting women's empowerment. Such an approach contributes to gender-equitable pathways to enhanced rural livelihoods.

Lessons Learned

This was an ambitious pilot project with a number of limitations, including a short timeline and needing to work around changes in Ethiopia's political situation at the time of the study. It was an interesting opportunity to bring together researchers from very different fields, and develop insights into our areas of work.

On the wider scale, scheduling of interviews is also difficult: avoiding times of the year when participants are busy preparing land or performing other on-farm activities, or are involved in religious activities. Conflicts with women's responsibilities around the home were inevitable, and despite reducing our intended schedule from whole-day to a few hours, interesting conversations were often cut short by women needing to return to other tasks. Part of how we overcame the loss of these data was to conduct key informant interviews in women's homes at times convenient to them, allowing them to carry on with tasks as they spoke to us. We also struggled to recruit equal numbers of male and female participants for the group interviews. Because women have primary responsibility for caring for chickens, men were less interested or motivated in participating in interviews; and those who attended focused more on intensive poultry production.

Methods

Previous agricultural studies into poultry have highlighted the difficulty in accessing women's knowledge (Aklilu et al. 2007; Meseret 2010), and researchers have suggested using women-only discussions to access this knowledge (Bagnol 2009). The approach of this pilot research was to conduct separate men and women structured group interviews to collect a broad range of views and stimulate discussion, and to undertake semi-structured individual interviews with women who had participated in the group interviews. Four ACGG sites around Addis Ababa were selected as being appropriate for the research. One men's group interview and one women's group interview were conducted in each location, for a total of 11 individual interviews carried out over the four sites.

Participant selection

Participants were selected through local ACGG agents, who invited men and women to attend interviews at a central location, usually the village development offices. We had requested six to eight participants for each group interview, although this number was not always possible to meet. We had particular problems with recruiting sufficient male participants, possibly a reflection of how chickens are considered to be important only for women.

Data collection

The questionnaire for group interviews and the semi-structured interview guide were produced through collaboration between an anthropologist (M.R.), a gender scientist (A.G.), and agricultural researchers from ACGG. This material identified both areas of interest, and culturally appropriate ways to reach these answers. An interpreter was hired who could speak both Amharic and Afan Oromo, to ensure that participants felt able to express themselves in their preferred language. Both questionnaire and interview guide were tested at one site, and refined to take into account timing and phrasing of questions. Recorded interviews were transcribed and translated by the interpreter who had carried out the interviews. These were reviewed and queried against notes from the day by M.R.

Data analysis

Qualitative data analysis was conducted using Nvivo 10 post-research. A coding structure was agreed by A.G. and M.R., who also independently test coded the pilot interview; agreement was found to be high. The remaining group interviews were coded by both A.G. and M.R. Individual interviews were coded by M.R. only.

Implications for Breeding

- Including traits such as chicken color or behavior that may appear secondary to breeding goals of, for example, increased productivity for enhanced livelihoods or nutrition, may be important to increase adoption. Not considering these traits may result in lack of adoption and consequently of progress on any set goal.
- Chicken-breeding programs in Ethiopia may need to develop chickens based on traits established at regional—as opposed to national level—in order to include traits that are culturally specific and increase the relevance of new breeds.
- Chicken-breeding programs may need to take into account preferences for chicken-raising systems rather than just traits. Understanding how these preferences are shaped by gender dynamics at community and household levels would again enhance the effectiveness of poultry interventions.
- Long-term studies such as the ACGG project present a good opportunity for researchers to work with farmers to bridge the gap in information and language, in particular to understand the types of different breeds and associated traits as well as how breeding programs are carried out.

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3.2 SELECTION

Participatory plant breeding and women empowerment for collective innovations and transformation towards equal and sustainable development: A case study from southwest China

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Introduction

As one of the three most important food crops in China, maize is cultivated in a wide range of climatic and geographical conditions, resulting in significant differences in maize cropping patterns and practices (Meng et al. 2006). At national level maize is mainly considered as feed and processing material. Yet it is different for small-scale farmers in southwest China, where production is challenged by biotic and abiotic stresses relating to market, agronomic, geographic, culture, and climatic conditions. Under these conditions maize is the main staple food, and its use as food, feed, and market income is given equal importance.

It is generally thought that continuous selection among crosses of genetically related cultivars has led to a narrowing of the genetic base of the crops on which modern agriculture depends. This contributed to the genetic erosion of the crop gene pools on which breeding is based (Sachs 2009). Modern maize breeding in China relies greatly on a few inbred lines (Li et al. 2002). There has been a fast spread of modern high-yielding hybrids throughout China over the past two decades, even in the remote mountainous regions of Guangxi and Yunnan provinces. However, there is still a demonstrated need for improved adaptation of both improved open pollen varieties (OPVs) and hybrids for socioeconomic and climate changes. Rural women have been playing important roles in the conservation and improvement of local varieties as the main cultivators and farm managers in the last two decades in China (Song 1998; Li et al. 2012) due to the male-dominant out-migration.

A participatory plant breeding (PPB) program in maize was initiated in 2000 in Guangxi to address small-scale farmers' needs, including women's specific needs and interests, for improved, locally adapted maize hybrids and OPVs, while also addressing the genetic narrowing issues and empowering women farmers. The aim of this case study is to show women's significant roles in local variety conservation and improvement through this PPB case. It illustrates the PPB process of the collaboration between small farmers (mainly women in our case) and breeders in order to improve the maize crop, including on-farm plant genetic resources conservation, variety selection, hybrid breeding, and seed production in China.

Background

China's rapid industrialization, urbanization, and marketization since the 1980s has meant that farmers cannot survive on farming alone due to small landholdings (averaging 0.6 ha). Therefore, many have adapted their coping strategies—for example, the "one household, two sectors" approach (husband in the city, wife on the farm) is common to many families. In this situation, rural women have come to take greater responsibility for agricultural production on top of their domestic and childcare duties. This is especially true in the poorer, remote mountain areas in southwest China, which has a rich agricultural biodiversity and food culture diversity. Our research (CCAP 2012) revealed that globalization, rapid development, and climate change have delivered serious impacts to local food systems: severe droughts, increased temperature, and extreme, local farming species and landraces were disappearing at an alarming rate, and the existing local seed systems were threatened. These developments have triggered a rise in challenges such as extreme poverty, food security and safety issues, increasing environmental degradation, and more frequent natural disasters in remote mountainous areas. Women, as the main cultivators, seed savers, and users, are the weather. As a result, most affected by climate changes. At the same time, they are the key custodians for farmer seeds and managers for diversified farming and local food systems.

Table 3.2.1 shows the migration situation in two southwest China provinces, Guangxi and Yunnan, that are home to most of China's rural poor, mountain ethnic minority communities with a rising trend of male out-migration. Over the past decade, the percentage of migrants in the total labor force in the communities has grown from 42.56% (2002) to 62.09% (2012)—a 20% increase. Men comprise the majority of migrants, though many young women migrate as well.

Table 3.2.1 Migrants in total labor force and women migrants in Guangxi and Yunnan

Year	2002	2007	2012
% migrants in total labor force	42.56	55.94	62.09
% women out of total migrants	38.48	39.84	42.06

Data source: Survey of 320 rural households in Guangxi and Yunnan provinces in 2013 (Song et al. 2016).

PPB Program and Key Roles of Farmers and Breeder Collaboration

To help women farmers in remote mountain villages conserve seeds and improve their preferred local varieties, while also addressing the challenge of a narrowing genetic base in formal breeding, the PPB project started in 2000. It focused on the province of Guangxi (southwest China) first, with the active collaboration of farmers in six villages, maize breeders from the Guangxi Maize Research Institute, the provincial public breeding institute, and the Chinese Academy of Agricultural Sciences, the national public breeding institute.

Breeders of both the provincial and national breeding institutes reported that the genetic base of maize hybrids had become dangerously narrow, which renders crops more vulnerable to pests and diseases, especially in the face of climate change. These breeders were invited to farmers' fields to discover for themselves farmers' varieties and their skills, knowledge, and expertise in managing genetic diversity.

Later in the process, farmers were invited to the Chinese Academy of Agricultural Sciences and the Guangxi Maize Research Institute to share their knowledge and experiences in seed selection with other professionals. During the exchange visits, the professional breeders discovered that the farmers had conserved and improved ‘Tuxpeno 1’ (a maize OPV released much earlier by the International Maize and Wheat Improvement Center). They also learned that one particular farmer, known as Aunt Pan from Wentan village, had improved a locally important variety of ‘Tuxpeno 1’ that had become widely popular in the surrounding local communities. Owing to these interactions, they began to realize that the local landraces that had been conserved on-farm in the Guangxi communities could be a potential source of valuable new breeding material for professional breeders in the country.

The breeders from the national and provincial institutes gradually acknowledged and appreciated that local farmers could become valuable partners in seed development and improvement. As a result, Aunt Pan joined the research team to continue improving ‘Tuxpeno 1’. From 2000 to 2004, the project gradually became a research program funded in part with Chinese resources, while the research team extended its activities to 20 new communities in Guangxi and to two additional provinces in the Southwest, Yunnan and Guizhou.

These communities were in more remote areas, and farmers in these villages reportedly conserved an even larger diversity of landraces. In some of the communities, the research team identified other experienced farmer-breeders, such as in Stone Village in Yunnan. These farmer-breeders are continuing and expanding the crop improvement efforts first started in Guangxi, with women playing a central role. Farmers in the participating villages benefited from the participatory experiments: they got access to scientific knowledge and improved seeds and were able to exchange these with farmers in surrounding villages, increasing the reach of benefits. Technically, PPB first focused on improving OPV maize varieties, then on maize hybrid development as well, with joint efforts from farmers and breeders. Table 3.2.2 shows the different and complementary roles by farmers (80% of whom are women) and breeders.

Table 3.2.2 Roles of farmers and breeders in a participatory maize breeding program, comparing population and hybrid breeding process

Breeding Steps	Population Breeding		Hybrid Breeding	
	Farmers	Breeders	Farmers	Breeders
Defining objectives				
• Evaluating existing varieties on-farm	X	X	X	X
• Prioritizing preferred traits and preferred diversity	X	X	X	X
Creating genetic variation				
• Collecting, maintaining, and/or creating diverse (base) populations	X	X	X	X
• Identifying crossing parents	X	X	X	X
• Making crossings:				
for OP breeding	X	X		
for hybrid breeding			–	X
— producing inbred lines			–	X
— making test crosses			–	X
— improving inbred lines			–	X
Selection (including test cross evaluation)				
• In field (on-station and in multilocational farmers' fields and kitchens)	X	X	X	X
• In lab (e.g., disease resistance and quality tests)	–	X	–	X
Testing and evaluating expected varieties	X	X	X	X
Registration	X	X	Agreement	X
Seed production[1]				
Parental seed provision	X	X	0	X
Parental seed development	X	X	X	0
On-farm seed production	X	X	X	

X = yes; – = no; gray shading = not applicable; 0 = depending on institutional options.
[1]Seed production-related activities were all done by women farmers.

Main PPB Activities, Process, and Results

The PPB activities include community-based landraces conservation, registration, seed bank, participatory variety selection, and community-based seed production. These activities have been continued today, and two community seed production bases that were started in 2005 have been carried out by women's groups successfully. In 2013, the PPB program developed into a multi-actor platform named "Farmer Seed Network" in China. It has scaled out to 36 villages in 10 provinces, conserved more than 1,500 food crop varieties (500 registered), improved 35 drought-resistant or quality landraces, and generated significant value for the women's groups from seed production and other value-adding activities. Figure 3.2.1 shows the process of the PPB scheme used to develop the PPB hybrid 'Guinuo 2006'.

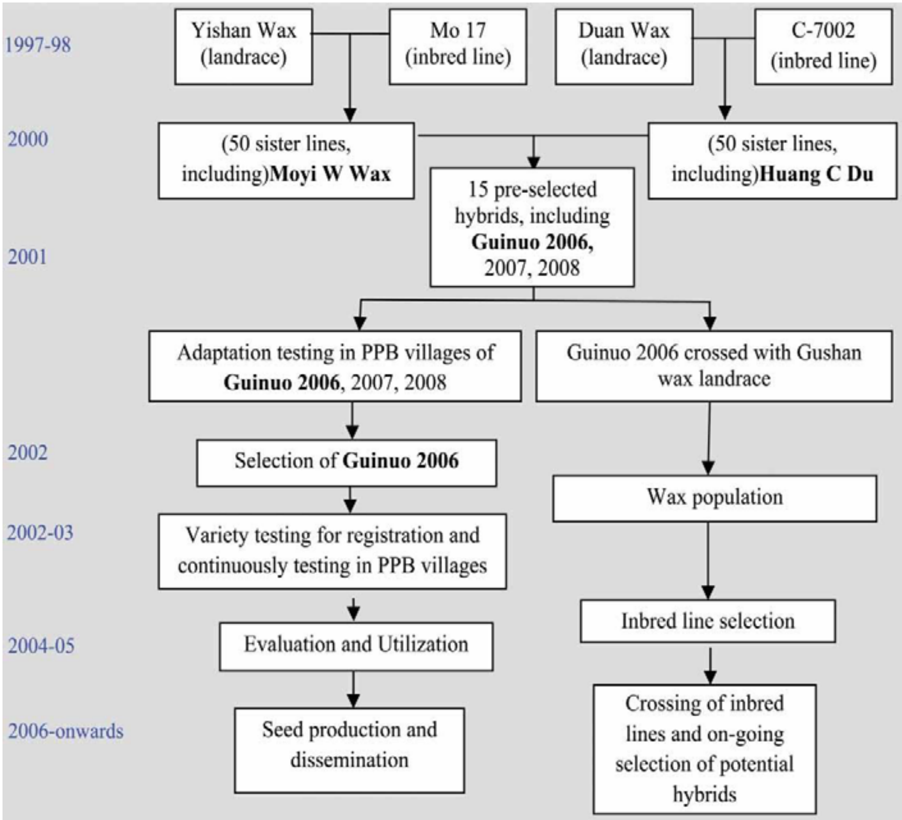

Figure 3.2.1 PPB scheme for the development of the hybrid 'Guinuo 2006'.

Adapted from Song and Vernooy (2010) and Li (2012).

PPB and Seed Production by Women Farmer's Groups

'Guinuo 2006' is the only hybrid among all the PPB varieties developed. It is a wax maize with high food quality and high market value. To help farmers save on the cost of seed, and as a way to share and redirect benefits to the farmers participating in the participatory breeding project, the PPB team worked with women farmer's groups to initiate community-based seed production of 'Guinuo 2006' in Guzhai village in Guangxi in 2007. Seed production was managed in both the production and the marketing part by women farmer's groups in the village. And though seed production has experienced some ups and downs, it has continuously generated a significant return for the women farmer seed producers. The women farmer's groups gradually grew into an active women-led farmer cooperative, carrying out circular farming and other value-adding and cultural activities in the region. In 2013, these PPB activities have expanded to other women's groups in Stone Village (a remote mountain village in northwestern Yunnan Province) through farmer-to-farmer exchanges facilitated by the PPB platform.

In Stone Village a women's group has been carrying out seed production of 'Guinuo 2006' since 2014. A series of PPB activities has been conducted by a women's group supported by other women's groups and scientists through knowledge-sharing. The Stone Village women's groups have conserved more than 50 food crop varieties and improved 10 drought-resistant or quality landraces, and has generated a significant amount of money from seed production. The group has also started learning ecological and organic farming practices from Guzhai village; it now plans to register as a women's farmer cooperative.

The case that a women's group in Guzhai village has developed into women-led farmer cooperatives in 10 years. The PPB experiences and knowledge have been disseminated to a women's group in a Yunnan village. This process helped to create an idea exchange with the women's cooperative in Guangxi for learning PPB, seed production, and organic farming and market linkages. These activities have increased women's income three times more than "modern" agriculture promoted in the last 30 years. More significant, the process has enhanced women's community-based collaboration in sharing production activities; managing natural resources; and linking to external information, market, and society. This is quite helpful for empowering women and their self-organization economically and socially. At the same time, it offers benefits related to climate change adaptation and sustainable development in those remote mountain areas.

Both cases benefit from strong technical support and capacity building, accompanied by targeted research. The project support for both the community cases in Guangxi and Yunnan is more focused on broad rural development than on technical and commercial motives. The work also benefits from interactions and collaborations with other cooperatives, restaurants, nongovernmental organizations, research centers and universities, and the government's agricultural extension service. The process of expansion is a capacity-building and empowering process for these women-led cooperatives and self-directed communities.

Conclusions and Recommendations

Farming women play crucial custodial roles in seed and food diversity all over the world. Women's reproductive roles as mothers and family keepers build their interest, expertise, and knowledge in seeds and food biodiversity which are a key basis for adaptation and sustainability. Moreover, they are making an essential contribution to the resilience and continuity of the world's ecologic and food systems. Survey data in southwest China confirm this: among smallholder farmers, 72% of women play a role in seed selection and storage (Song et al. 2016).

The PPB initiative illustrates the merits of integrating PPB activities into the local farmer seed systems—by allowing farmers (mainly women) to work together with scientists. As well, the process represents an important institutional innovation for linking the formal and farmer seeds systems, empowering women farmers, and enhancing scientists' knowledge. The case study has shown that women farmers are not only able to conduct OPVs conservation and improvement in their field, but also to participate in some stages of hybrid breeding and seed production with technical support and benefit-sharing from breeders.

The fact that hybrid breeding in some stages is technically complicated should not prevent the involvement of farmers in the early stages of the breeding cycle in order to (1) discuss preferred starting material and prioritize traits, (2) evaluate and select test crosses on-station, and (3) enable the collaborating farmers to test the preferred crosses on-farm and also in seed production. Nevertheless, for smallholder farmers, OPVs and more diversified varieties and crops are more important and hybrids could be an option to meet women farmers' multiple needs (e.g., nutrition and income). The Guangxi PPB example shows how hybrid and OPV improvement can be integrated as parallel efforts in one PPB breeding program for both supporting multiple functionality of diversified farming and food systems and empowering women farmers.

The case study illustrates an important rural development and women's empowerment pathway to alleviate poverty, improve food security, and better prepare for climate change in the mountain areas of southwest China. PPB can also be a good entry for locally driven adaptation and empowerment process in which farmers, led by women, have improved their local varieties and enhanced their capacity to deliberate about choices of action, experiment with options, create new practices, and enlarge their network of horizontal relationships with other actors. As a result, farmers realize more social capital and autonomy for collective innovations and transformation toward equitable and sustainable development.

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Farmer engagement in culinary testing and grain-quality evaluations provides crucial information for sorghum breeding strategies in Mali

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Introduction

Access to and adoption of improved varieties by smallholder producers in marginal environments is one of the most important approaches to increasing crop production and household food security. Improved varieties have the potential to increase yields through resistance to abiotic and biotic stresses, hybrid vigor, and environmental adaptation. However, ensuring that improved varieties and seed reach smallholders *and* meet their production and consumption needs is a long and ongoing challenge that requires rethinking approaches to plant breeding and market-driven seed markets. Conventional breeding programs in industrial agricultural regions develop varieties suitable to largely homogenous landscapes, in which the use of external inputs further limits environmental variation and reduces risks associated with agricultural production. The riskier, if more environmentally sound, internal controls of ecological processes are replaced with external inputs such as fertilizers and pesticides (Robertson and Swinton 2005). Furthermore, the farm household consumption needs, as well as those of consumers, are divested from production. For example, until recently, dry bean (*Phaseolus vulgaris* L.) varietal traits in the United States were selected based on field performance, suitability to mechanized field operations, and canning quality. Attributes such as taste, or quality as a dried bean or alternative flour, or cooking time were not considered in breeding programs until recently (Cichy et al. 2015; Meadows 2016). For these reasons and others, the current ecological and socio-political environments in which smallholder- and subsistence-farmers cultivate crops differ considerably from those targeted by conventional "industrialized" breeding programs.

The varieties developed by conventional models of crop breeding, which focus on mechanized labor and high-input conditions that reduce agricultural risk, have largely been transferred to regions and producers that do not have these luxuries. In these more marginal regions, environmental variation at both the landscape and field level, limited economic resources for smallholder farmers, poor infrastructure, poor governance, and few risk mitigation opportunities (Charles et al. 2010) render such a model unsuccessful. In addition, production needs are linked to consumption needs and gender: smallholder selection criteria for a single variety often include a composite of consumption, processing, and production attributes that meet the requirements of different members of the household. Finally, underlying cultural preferences and social structures such as gendered preferences that inform farmer selection criteria are often unknown to breeders, or are not part of breeders' standards for selection (Mulatu and Zelleke 2002). Although breeding programs have been adapted by various means to include on-farm testing, farmer evaluations, and use of local germplasm as source material for breeding, high levels of adoption are still evasive. A proven adaptation to conventional breeding program includes PPB and PVS, both of which have, when implemented with appropriate tools, addressed some of these ecological and social hurdles through farmer involvement.

PPB and PVS are pursued to assure relevance of the breeding program and more effectively develop varieties that can provide value to the targeted farmers. The link between farmer and researcher provides a means to foster communication and develop shared outcomes that equate to preferred, "adoption-worthy" varieties. Even so, in this intentional process of creating and learning with farmers, different actors in the process can be marginalized or left out of trait targeting if social structures are overlooked or incomplete methods are used. As the case study on women's inclusion in sorghum (*Sorghum bicolor* L.) variety testing in Mali clearly demonstrates, the breeding program progressively incorporated women through PVS tools, in combination with other qualitative and quantitative tools, long-term community engagement, and dynamic dialogues that provided data and insights for changes in the breeding program to fit the regional context. In the present case study, we explore in detail the postharvest participatory culinary test methods and grain-quality evaluations analysis of qualitative feedback from participants. We examine the importance of these culinary tests for guiding the sorghum breeding strategy in Mali, with attention to gender and in-depth qualitative assessments under pertinent contextual conditions.

Background

The sorghum breeding program in Mali was confronted with a major dilemma regarding which germplasm to use as a foundation for future variety development (see Rattunde et al., this case study synthesis). Sorghum breeding advances in the United States, Sudan, India, and Australia were all achieved within the caudatum and kafir races, two of the five major sorghum races. Thus, most of the improved varieties tested by breeders in Mali and West Africa in general until 1995 were derived from those races. But the local varieties grown in the Sudan Savannah were predominantly of the guinea race, which at the time was rarely used for breeding new varieties. Was it necessary for the program to shift its efforts to a new race?

Methods

The sorghum breeding program in Mali initiated postharvest culinary tests as an extension of the participatory variety evaluations conducted in farmers' fields. The processing and food quality of the most agronomically promising varieties were tested to ensure that advanced and released varieties would be acceptable for food preparation. Prior to the first culinary test, interviews and engagement with communities over multiple years and smaller studies revealed that women had specific criteria for the storage, processing, and preparation of sorghum that were not being captured in field trials. Building on these findings from engagement with communities, the procedures for the culinary evaluations were developed to consider quantitative and qualitative measurements of multiple grain quality attributes, including losses during the decortication process; varietal differences in flour-to-grit ratios; the swelling potential (i.e., the capacity to absorb water) of the stiff porridge (*tô*); and characteristics such as glume opening, insect damage, and grain hardness. The details of the methodology are described in a separate paper (Isaacs et al., in preparation).

The culinary test is conducted once a year, several months before planting, and is a day-long event in the community in which all are welcome and contribute to the process. The team facilitating the culinary tests always includes breeders and other officers from the national research programs and the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), partners from the national nongovernmental organizations, and farmer–animators from the community. Scientists with expertise in nutrition or social sciences also participated when possible, especially during the development of the process.

Promising lines or varieties from the field trials are identified by the growers, and in a plenary discussion, four of the most promising are selected for the culinary test and a local check is included. The culinary test focuses on the processing and preparation of *tô*, a porridge that is ubiquitous and eaten daily across rural communities in Mali. The entire process of preparing the five varieties for *tô*, including milling, winnowing, cooking, and finally sampling the *tô*, is replicated in three processing groups consisting solely of women. During each phase, multiple measures are taken: the amount of time to decorticate or cook; evaluation of the color of the product at each stage; weights of bran, grits, flour, and the amount of water, flour, and potash added; grain hardness; the processing groups' evaluation of the difficulty of preparing the *tô*; meal economy; global appreciation; and finally the sensory qualities. In addition, open-ended comments from each replication team, related to each phase of the above measures, are recorded. The five varieties prepared in each replication are randomly numbered to ensure anonymity.

Once all replications of the varieties are prepared, each replication is "blindly" evaluated individually for sensory qualities by 25 men and women from the community. They evaluate each variety and replication for taste, consistency of the *tô*, color, and a global score, using a scale of 1–3 (very good, acceptable, unacceptable). These tallies are discussed with the community, and further data are collected. *Tô* prepared for the evening meal is also saved and eaten in the morning; thus the varieties are tested in the morning for quality of conservation.

An evaluation of the effectiveness of the culinary tests was conducted in 2007 and 2008 across three regions in order to validate the method for determining preferred culinary traits and appropriate varieties (Isaacs et al., in preparation). In that study, the same varieties were used across the three regions. Results indicated that the varieties varied greatly in the ratings tasters gave them, and these ratings are not the same between villages nor regions. The three qualities (taste, consistency, and color) were of essential importance, although taste was the best predictor of the global score. On the basis of these differences, culinary tests continue to take place each year and grain quality is a key selection criterion. Furthermore, that study revealed there were clear differences between varieties in the amount of bran and the ratios of flour to grits, yet these were relatively consistent across regions. Thus, future culinary tests are focused on farmer groups' selection of the promising varieties preferred in their communities. Here we present lessons learned from the culinary tests conducted over the years with complementary data from the culinary test conducted in 2015, in which there was less overlap between regions in the varieties selected by farmers.

Results

The culinary test was designed to take into consideration women's preferences and experiences during the processing and preparation of sorghum grain. Their knowledge about these processes and the identification of important traits for better household food security were key to improving the breeding program.

Decortication and bran residues

Both the measurement of losses from decortication and the women's descriptions of the grain during this process revealed new insights about how women think about yield. From the evaluations and discussions around the decortication process it was clear that if a variety had high decortication losses, it was not appreciated as this reduced the final yield available for consumption. For example, in a 2015 analysis of the percent of bran in the 32 varieties tested, the quantity of bran ranged from 11% to 31% between varieties (Figure 3.2.2). Local varieties such as 'Seguetana', or the new variety 'Lampe', had lower amounts of bran (14% and 11%, respectively), whereas new varieties 'Peke' and 'Kossa' had over 31%. These varieties with higher amounts of bran were not appreciated by women because they consider the actual yield of the grain after decortication, a different measure than the yield data collected at harvest time and after threshing. Even varieties with a midrange of yield loss from bran, such as 'Djeleba' (21%), were not liked by women. Of 'Djeleba', one group said, "It is easy to decorticate, but it breaks and gives a lot of bran." Discussions also revealed that if the grain breaks too much during decortification, it is not appreciated because the chafe sticks to the broken grain, making it difficult to remove or produce flour, thus reducing the final food yield.

The descriptions women gave also showed that they make trade-offs concerning traits. For example, 'Dalari' is a variety that had 27% yield losses from bran on average. Yet women also liked it because it returned a good value from water absorption: "It's difficult to decorticate, but the hard grain absorbs a lot of water so it has a high value in terms of meal and food." This reveals another key food yield factor for women: if a variety absorbs more water, it swells more and creates more volume of food. The wrong combination of these traits can lead to rejection as well. For example, women said the variety 'Mamba' absorbs a lot of water but breaks too easily when decorticating. The value gained from good absorption was lost because too many of the grains broke, which increased the time and labor needed to process the grain into flour as well as reducing the potential quantity of flour.

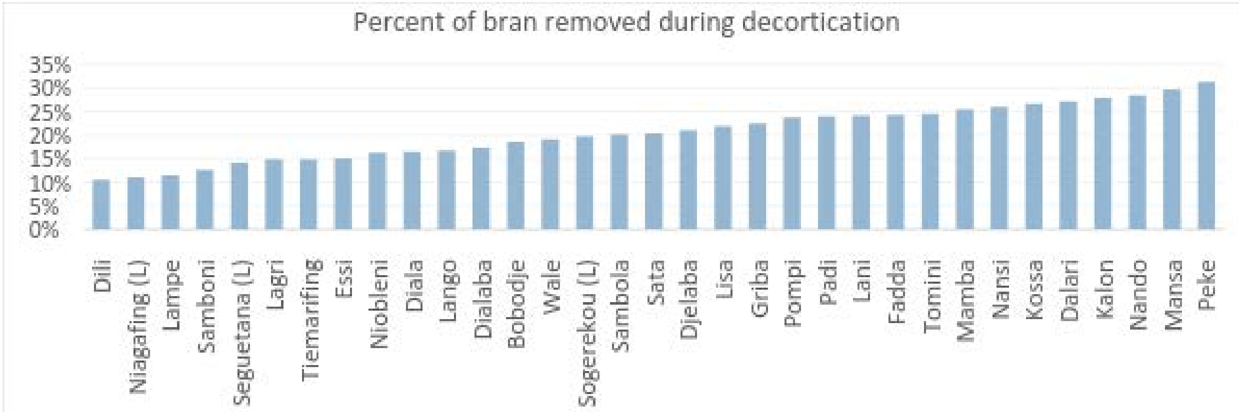

Figure 3.2.2 Percent weight (g) of bran removed during decortication of 32 varieties in Mali in 2015.

The richness of the data from both the qualitative descriptions and the ability to quantify the values strengthened the research twofold: the quantitative data lend confidence to the variations across time and space, and the qualitative data provide descriptions that answers why these measures matter. Furthermore, the data give breeders materials to work with. If a variety is appreciated for its water absorption capacity but had poor grain hardness, it may be a useful candidate for crosses or to identify grain properties associated with water absorption capacity.

Ratio of grits to flour

The culinary tests have shown how preferences for the type of product rendered from milling the varieties varies across villages and regions. After decorticating, women pound the sorghum grain further and winnow it three times until the flour and grits are sorted. Generally, the higher the flour ratio, the more preferred the variety. But the presence of grits is also important, and the preferred ratio varies between households. In Mandé region, the percentage of grits in the varieties tested in 2015 ranged 18–34%, with the local variety 'Tiemarifing' having 34% (Figure 3.2.3). In Koutiala, the local variety 'Sogerekou' had 24% grits and the varieties ranged 19–45%. Although the culinary test is designed to use the flour in order to make the commonly eaten repast *tô*, there are also traditional dishes that use the grits. Discussion and feedback sessions revealed that some villages and families prefer to have a higher proportion of grits than others for these dishes. Other interesting factors arise from the descriptions of the milling, such as there are some varieties that "jump" out of the mortar more than others, causing losses. This type of factor is not easily quantifiable or something associated with another trait such as hardness, suggesting that practical tests offer an invaluable opportunity for processors to really experiment and test the varieties.

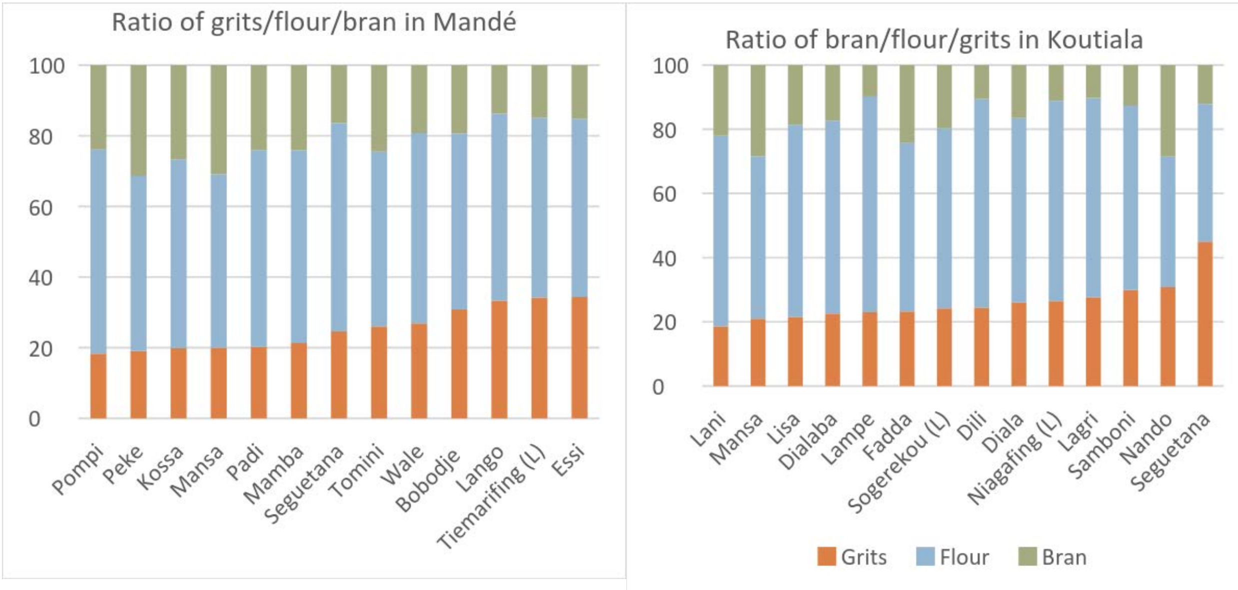

Figure 3.2.3 Ratio of flour to grits of 15 varieties tested in Mandé and Koutiala, Mali, in 2015.

Cooking the *tô*

The process of uniformly cooking the *tô* together provides insights into women's preferences in terms of color, the ease of mixing or creating a *tô* of good consistency, and again, the value or "yield" of the *tô*. Throughout the entire process of preparing the *tô*, and again during descriptions from the actual cooking, women discuss elements of economy—namely the idea that the variety produces more food through water absorption capacity, the consistency of the *tô*, or the flour yield. During the cooking, in the majority of statements made, women refer to the variety as a good, average, or poor value for *tô*. For example, a group of women in 2015 said of 'Sata', it is "easy mixing, the *tô* is sticky and of soft consistency, but it absorbs little water so it is not economical in meals." Or, in Siranikoro, Mandé, the women said 'Tiemarifing' was "easy to mix, the white color is good but it's only a little economic." Though this variety had a good color, it did not have a high food yield. Women in this context define varieties in terms of the quality and, in particular, the quantity of food delivered. They do this through the evaluation of attributes not typically considered in traditional breeding programs or even in cooking tests. Key here is that an engaging culinary test has captured the contextual and social *valuations* of sorghum. Malian communities conceptualize the yield of a sorghum variety far beyond the amount of grain weighed at harvest time.

Women's labor and time

Throughout the cooking test, the time necessary to decorticate, mill, and prepare the *tô* is recorded, providing comparable data for each variety, stage, and replication. The women get a strong sense of the differences between the varieties so they can choose ones that work for their situations. In 2015, most varieties required 6–7 min to decorticate, with a range of 4–10 min. The time required to cook the small portion of *tô* varied much more. Comparing the cooking time across regions is not appropriate in this situation, as local resources such as fuel wood are used throughout the test and the quality of the wood may vary between sites. The results can be verified through the replications, however. To show an example of how cooking time may vary, 2015 results from Kiffosso, Koutiala, showed a range of cooking times of 15–31 min; in another community the range was 13–19 min (Table 3.2.3).

Table 3.2.3 Average time required to decorticate sorghum grain and cook the *tô* in Kiffosso, Koutiala, 2015

	Time (min)	
Variety	**Decorticate**	**Cook**
Diala	6	26
Dili	7	31
Mansa	7	15
Nando	7	28
Niagafing	6	28

Well documented around the world, women's labor and time in smallholder households are highly valuable because they manage so many aspects of the household's livelihood and well-being, at the hearth and in the field. Efficiency is essential for women, and the shorter time it takes to decorticate or cook the porridge, the more time they have for other activities. One factor less documented is the sheer volume of food production on a daily basis in Malian UPAs (units of agricultural production), which can consist of upwards to 100 members. When processing grain and preparing food at such a large scale, even if broken down in smaller units, the few extra minutes required to decorticate or mill sorghum grain become substantial. To put this in perspective, imagine peeling five twisted, multi-fingered carrots for your family of five. This is a little onerous, but not very time consuming. Now imagine peeling 100 of those twisted carrots for the UPA, versus 100 uniformly shaped carrots. The time savings from peeling a "perfectly" shaped carrot on such a large scale are monumental; likewise, the potential gains in efficiency (both in terms of time and fuel) when sorghum processing is quicker are a big gain for women. The culinary tests provide women with the opportunity to test new varieties in terms of time and efficiency, and ensures that further breeding time is not wasted on varieties that do not meet those household needs.

Sensory scores

Finally, the sensory scores that take place at the end of the preparation of the *tô* provide valuable data from both men and women regarding the taste, color, and consistency. At the end of the individual evaluations, the community comes together to discuss in more depth the *tô* and provide any additional feedback. These sessions lend insights into qualities that are key for a variety to be adopted. *Tô* that is black or red is most often rejected, as are varieties that do not have an appropriate texture. For example, the variety 'Dialaba' had the highest total sensory score in Koutiala in 2015 (Figure 3.2.4). The *tô* was appreciated for its white color, consistency, and ease of mixing.

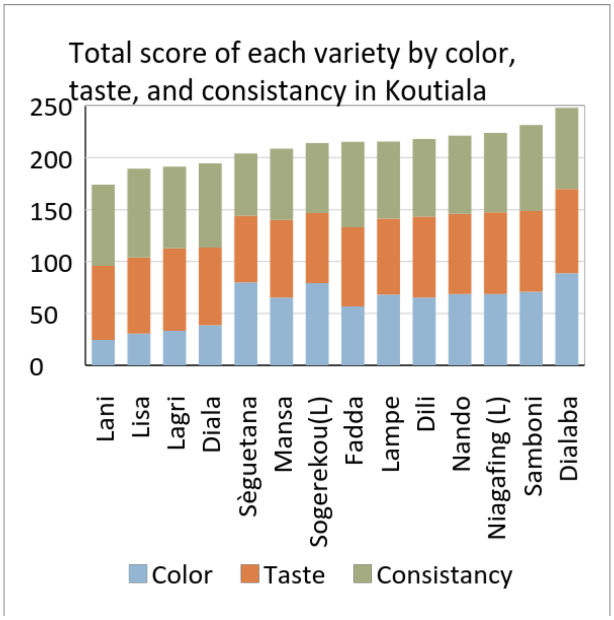

Figure 3.2.4 Sensory quality scores from Koutiala in 2015.

Conclusions and Implications for Breeding

The most fundamental long-term change from involving women in the trial evaluations has come from the detailed understanding of the sorghum grain-processing procedures: the quantification of the decortication losses and the wide range of variability found among the varieties tested. It became clear that farmers cannot adopt a variety that may have 10–20% more grain if its decortication losses are 10–20% more than the losses from the local variety. This is particularly true if, in addition, the new variety has more storage losses during the dry season due to susceptibility to storage pests and if food preparation requires more time or effort. Thus, during the culinary evaluations, the decortication losses and the flour-to-grit ratios are now always quantified to ensure that newly released varieties do have a clear advantage and benefits for household food security. In addition, to ensure that only varieties with appropriate grain quality reach the variety-testing stage, experienced women farmers are invited to the research station to provide their visual assessment of grain qualities of early generation material. Inclusion of multiple stakeholders in the process, including national research scientists, has also helped to inform their breeding efforts at the country level.

Significantly, these results showed that many new varieties, especially of the caudatum race, rarely met the quality standards of Malian women due to differences in the quality and quantity of the flour, consistency of the *tô*, and the hardness of the grain. On the basis of these findings, and considering requirements for adaptation to biotic and abiotic stresses, the sorghum breeding program decided to focus its breeding activities on the genetic diversity within the guinea race, while using the improved caudatum breeding material as source material for specific traits (as documented by Kante et al. 2017).

This fundamental shift had a range of consequences for the selection strategy of the program that cannot be elaborated here in detail.

The findings from the culinary tests show that women evaluate the quality of a variety for processing and cooking, and that their valuation of the varietal yield extends far beyond the agronomic yield. This tool has been instrumental in revealing how women evaluate sorghum varieties and demonstrates that people in different contexts conceptualize and measure the value of crops distinctly from the classical science–agronomic perspective. To ensure adoption of varieties that are resistant to the abiotic and biotic stresses typical of marginalized environments, an in-depth understanding of men and women's trait preferences are essential. Gender-focused evaluations such as the culinary test, combined with increased access to new varieties through trials and seed cooperatives, generate evolving information for breeding objectives and have contributed to increased adoption of improved varieties in Mali. Continuation of these trials and culinary tests ensures that the breeding program maintains a current pulse on the needs of producers, consumers, and marketers, as presumably their needs are dynamic and changing with the growth of local markets or other social and cultural shifts.

There are key traits that need to be part of the breeding process; but these tests have also demonstrated that there is variation in individual community and household needs. Providing the communities with diverse varieties to test in the field and during processing ensures that the selected varieties capture the range of characteristics expected by the household as a whole. When men and women can test the varieties themselves, in a relatively low-risk situation, the diverse varietal options allow them to make important trade-off decisions specific to their household and community needs. This removes what may potentially be a guessing-game for breeders. If only a select number of varieties are advanced or released, and/or seed sellers or producers only offer select varieties that meet their production needs, the potential diversity available narrows substantially and adoption may in fact be lower because they only suit a certain segment of the population. The combination of providing multiple varieties within a general selection criteria and collecting trait preferences from both women and men through a range of feedback mechanisms such as the culinary test, increases the chances of approval, availability, and subsequent adoption by farmers. The culinary test is a feedback mechanism that ensures that women's unique trait criteria and varietal preferences are captured, and the inclusion of women in the evaluation process strengthens everyone's knowledge about the varieties and their potential.

Lessons Learned

- Men and women evaluate sorghum varieties from perspectives that are based on their roles and responsibilities in the household.
- Although growers are always interested in "yield" first and foremost, how yield is conceptualized by end-users may be quite distinct from how a researcher, or even the principal grower, measures it.

- Decortication losses, water absorption potential, and proportions of flour and grit were key considerations for grain processors.
- Individual households make trade-offs in these traits, and a diversity of varieties to choose from can improve the likelihood of meeting a household's needs.
- Adoption of a new variety that does not encapsulate attributes from growers and processors is unlikely in smallholder systems where the crop is produced primarily for consumption.
- Insights from the culinary tests provide a constant feedback mechanism to researchers, ensuring that breeding remains dynamic and viable to the needs of various actors.

Recommendations

- The culinary tests (see example in Box 3.2.1) may appear daunting in scale, but the insights gained are invaluable to breeders. They are also an important platform for recognizing and valuing the role of women and different user groups.
- Care should be taken to ensure that data collected can be analyzed: scoring protocols must be conducive to analysis (see Coe 2010). Descriptions in qualitative data notes must indicate whether a quality discussed is favorable or not, and why.

Box 3.2.1 Culinary Test

A DYNAMIC FOOD LAB BROUGHT TO AND SHAPED BY THE COMMUNITY: The culinary test is an opportunity for community members to evaluate varieties for processing and cooking; using their own criteria under their typical farmstead conditions.

FREQUENCY AND TIMING: One time with each output of new varieties or lines; before growers are planning for the next planting.

WHICH VARIETIES: New ones and local checks selected by the community.

TYPES OF DATA COLLECTED:

- Quantitative—weights, times, and rating
- Qualitative—descriptions and impressions of characteristics at each stage, discussion groups, short feedback.

EXAMPLES OF DATA COLLECTED WITH SORGHUM: Grain characteristics (glume opening, insect attacks, presence of smut), decortication ease and duration, decortication impressions, bran weight, milling time and ease, milling impressions, coarseness and quality of flour and grits, global evaluation, sensory evaluations (taste, consistency, color, global), economy of the meal.

CONSIDERATIONS:

- Groups selecting varieties for inclusion in the culinary test need to include multiple types of end-users.
- Together with the group, identify commonly prepared foods and select the dish to be prepared and evaluated.
- With the group, determine the important characteristics of processing and cooking that will be measured; as a researcher identify methods to compare values in the lab for validation and transmittal to trait targeting for breeding.
- Ensure that intersectionalities of gender are considered in the culinary groups (older and younger members, caste, status, etc.).
- There will be slight variations; for example, in the quantity of potash added, or the quality of the fuel wood between sites.
- In qualitative discovery, try to learn the underlying meaning and ask w*hy?* Why is a trait good, what about *x* makes it a good variety? How can you tell it has this trait? What do you mean by that? These types of questions improve understanding and help to identify what the actual attributes add to trait targeting in the breeding process.

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3.3 TESTING EXPERIMENTAL VARIETIES

Gender-differentiated preferences in breeding for new *matooke* hybrids in Uganda

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Introduction

Uganda is the largest banana producer and consumer in SSA (IITA 2009), and cooking bananas (*Musa* sp.), locally known as *matooke*, are the country's main staple food. The crop, which is cultivated primarily for its fruit and used for food, juice, and brew, is consumed at a daily rate of 0.5–1 kg/person. *Matooke* forms an indispensable part of life, and millions of Ugandans rely on banana as part of their livelihoods and daily dietary requirements. Approximately 75% of farmers cultivate banana on 1.5m ha, which accounts for over 38% of utilized arable land (Nowankunda and Tushemereirwe 2004; Jogo et al. 2013). When grown under perennial production systems, bananas produce fruit all year-round, thus bridging the hunger gap between crop harvests (IITA 2009). Bananas also maintain soil cover throughout the year, and their biomass is used for mulch and soil fertility conservation. In mixed farming systems, bananas are used as ground shade and a nurse-crop for a range of shade-loving crops, including cocoa and coffee.

Over the last five decades, banana yields have decreased, with average yields not exceeding 30% of the crop's potential of over 60–70 t/ha/year (van Asten et al. 2005). A combination of abiotic and biotic stresses constrains banana production in Uganda. The major abiotic stresses include nutrient deficiencies and moisture limitations (drought stress). Banana production also suffers from many biotic stresses, the most important being black Sigatoka, bacterial wilt, Fusarium wilt, nematodes, weevil, and banana bunchy top disease (Tushemereirwe et al. 2003; Swennen et al. 2013). The devastating effects of these pests and diseases pose a great threat to the sustainability of banana production in the region (Edmeades et al. 2007). Globally, host-plant resistance has been identified as the most feasible intervention for pests and diseases management for many smallholder farmers who grow the bulk of the crop (Lorenzen et al. 2010; Ssali et al. 2010). Breeding for new banana varieties has thus been identified by the National Banana Research Programme as the most important intervention to resolve the pest and disease problems. However, the process of ensuring multiple desirable attributes during breeding for new varieties can often be complex and also poses a challenge to subsistence farmers. For instance, when improved varieties are harvested, there is a risk their market value will not be comparable to other local cultivars, which could impact the livelihoods of farmers who depend on banana as a source of income. This is particularly true for a crop like banana due to its low genetic variability, polyploidy nature, and the low levels of female and male fertility in most widely grown triploid clones (Lorenzen et al. 2010; Ssali et al. 2016).

Background

A key driver for increasing productivity is the adoption of improved agricultural technologies, such as improved varieties (Minten and Barrett 2008). Despite cultivated bananas having low levels of male and female fertility, it is possible to breed bananas using conventional techniques. NARO and partners like IITA and Bioversity International have embarked on improving East African highland cooking bananas for high yields and resistance to disease and pests, with products of these efforts at various levels of development. The promising banana hybrids resulting from breeding efforts initiated in 1994 were introduced to communities in 2008 during on-farm testing and evaluation. The progenies were evaluated in early evaluation trials at the Kawanda research station of NARO for agronomic performance and response to black Sigatoka (Ssali et al. 2010). Eighteen promising hybrids ('M1' to 'M10' and 'M12' to 'M18' with AAA genome and 'M11' with AAAA genome) were selected for a participatory on-farm evaluation. The materials were planted in farmers' fields and evaluated against a local check 'Mbwazirume'. The selected host farmers were trained in field preparation and general banana management. Field days were conducted to allow farmers to participate in evaluation and selection based on criteria agreed upon by the stakeholders (including farmers, extensionists, and researchers) participating in the selection.

As mentioned, the breeding focus was mainly on high yield (measured by bunch size/weight), resistance to pest and disease, and early maturity. With early-maturing, resistant or tolerant, and high-yielding varieties, breeding aimed to deliver new varieties that would increase production and contribute to addressing food security challenges, which remains an issue faced by women in most households. There is evidence that women in most of subsistence-farming households in Uganda are heavily involved in the decision-making around banana production (Edmeades et al. 2007; Addison and Schnurr 2016). For instance, the cultivars grown in 50% of the households in lowland areas in Uganda are chosen by women. As such, pertinent gender-differentiated needs and trait preferences became more visible during on-farm evaluation and selection. Although men were interested in a big bunch that they could easily sell in the market, women preferred a new *matooke* hybrid variety with better consumption attributes such as rich flavor, soft texture, and deep yellow color when steamed.

Methods

Matooke hybrids resulted from conventional banana breeding. The process involved the transfer of pollen grains from resistant, fertile diploid male plants to the female flowers of triploid clones with female fertility, to obtain resistant tetraploid hybrids (Cheeseman 1932; Jones 2000; Ortiz et al. 1995). The resultant progenies then go through several rounds of selection, starting with the early evaluation trial, where the selection is based on the agronomic performance of single clones. The genotypes selected in the early evaluation trial selection are further evaluated for black Sigatoka response, yield, and consumer acceptability in the preliminary yield trial before the participatory on-farm evaluation with farmers (Nowankunda et al. 2015; Ssali et al. 2010).

During the on-farm trials, advantages and disadvantages of the different varieties were evaluated in trait preference studies. A criterion for evaluation was developed and farmers scored the different varieties for field and sensory traits. Focus group discussions were conducted during which pairwise ranking for variety attributes was done to determine which traits farmers consider most highly in selecting banana varieties. Therefore, mixed methods (a blend of quantitative and qualitative methods and tools) were used to collect data and analyze farmers' needs, preferences, and selection for banana hybrids.

Owing to the gender differences that emerged, sensory and consumer acceptability evaluation studies were introduced during on-farm testing and evaluation. The sensory evaluation exercise was conducted across multilocation trials with both men and women. The sensory evaluations were done during farmer field days conducted at a host farmer's plot. Bunches were harvested from farmers' fields and used for sensory evaluation. Participants mainly included producer consumers (consumers who produce, consume, and sell the surplus). The sensory exercises aimed to establish the acceptability of the hybrids. The participants were presented with cooked banana variety samples (presented in random order and coded with random numbers) and were asked to do visual and taste evaluations while filling out the score sheet. Participants assessed and scored their perception for sensory parameters; namely color of the food when cooked (appearance), taste, flavor, and texture based on a five-point Likert scale (5 = excellent, 4 = good, 3 = fair, 2 = bad, and 1 = very bad) (Dadzie and Orchard 1997). The scores were later collapsed into three categories (bad, fair, good) at analytical level for meaningful interpretation. Overall acceptability was also rated on a scale ranging from 5 (very acceptable) to 1 (not acceptable at all). The sensory evaluation exercises were followed by a field visit during which participants were allowed to visually inspect the physical appearance, such as bunch size, and other plant characteristics, such as finger shape, and the leaves for each variety.

Results

Broadly, the results from the sensory evaluation showed that hybrid bananas differed significantly with regard to different sensory attributes. In terms of overall acceptability, hybrid 'M9' scored significantly higher compared with other hybrid varieties (Akankwasa et al. 2013a, 2013b). Therefore, further analysis was done to establish whether there were any differences in trait preferences for 'M9' between men and women with regard to the different consumption attributes. The results indicate that although most of the traits were equally appreciated by both men and women, differences exist. There was a greater appreciation of food quality traits like taste, flavor, and color of the food when cooked by women (Figure 3.3.1). Further, results suggest that there was a significant difference between women and men in the overall acceptability score for hybrid 'M9', implying that women tended to appreciate hybrid 'M9' more than men did (Figure 3.3.2). Low acceptability by men could be attributed to the failure of 'M9', despite the big bunch, to attract a higher market price.

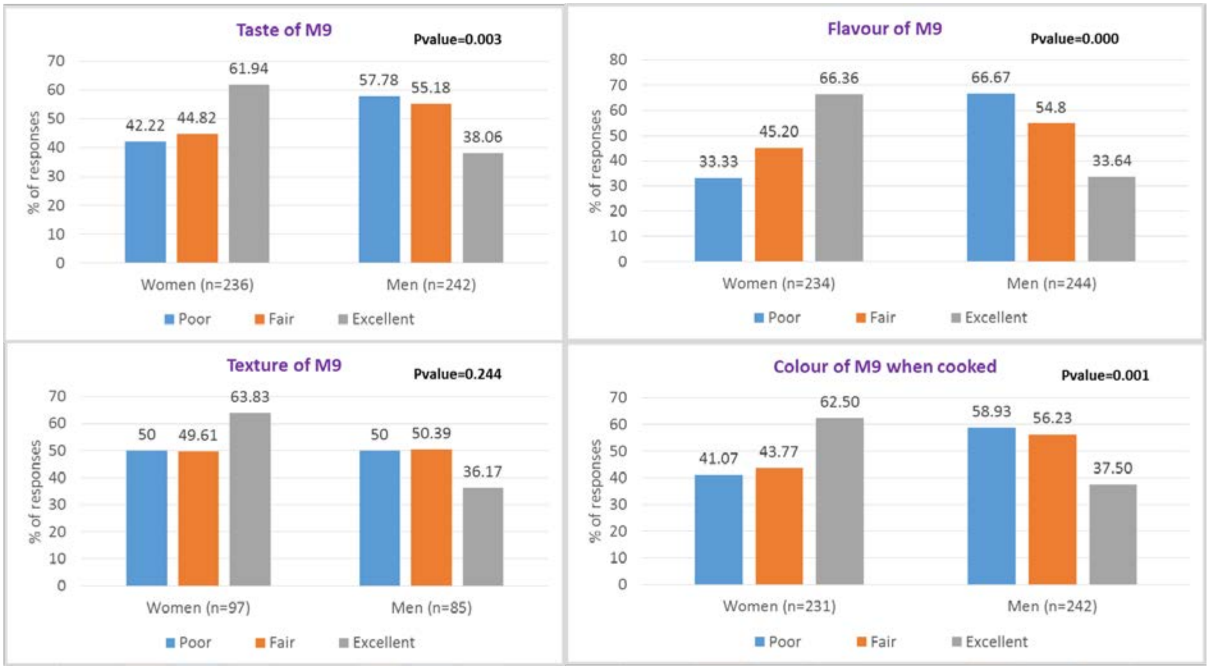

Figure 3.3.1 Evaluation of sensory quality attributes of 'M9' banana hybrid in Uganda by men and women.

Additionally, the sensory and quality attribute studies also revealed that about 78% of the *matooke* hybrid varieties evaluated for release had low heat-retaining capacity, which made the food harden very fast when served. The hybrids required prolonged cooking time to soften the texture, hence the need for more labor time to gather fuelwood which became an additional challenge to the already overburdened women. Although men are reluctant to produce *matooke* hybrids due to low market demand, women who take primary responsibility for food provision in their households are gaining interest in the variety by tailoring it to their needs. Women continue to innovate on diverse utilization, especially on preparation and cooking methods that enrich taste, color, texture, and flavor.

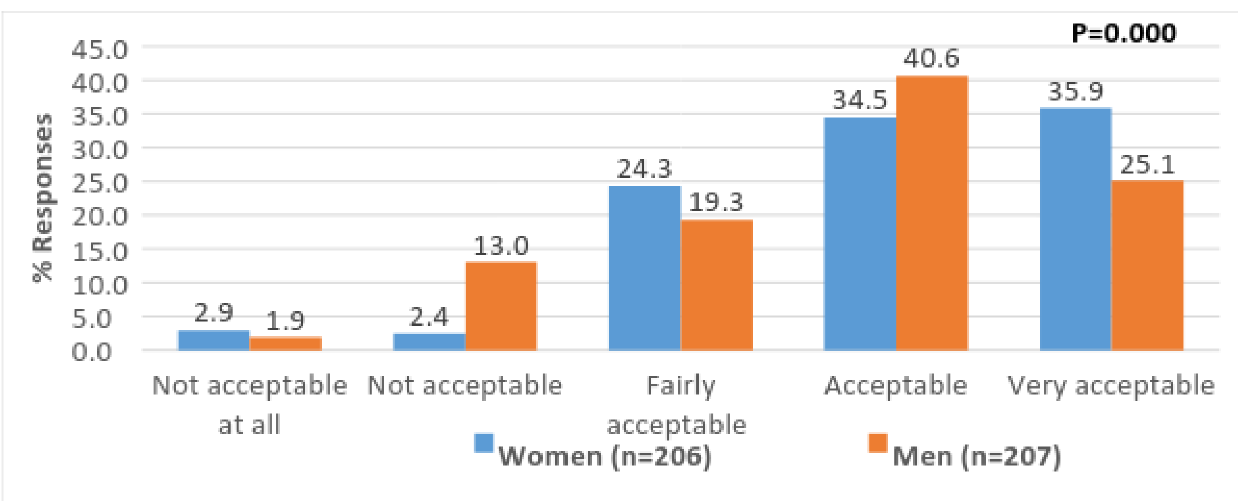

Figure 3.3.2 Overall acceptability of 'M9' *matooke* hybrid by men and women.

As a result of the gender-specific needs that emerged, only one *matooke* hybrid (evaluated under the code 'M9') out of 18 promising hybrids evaluated was released by the national variety release committee in 2010 as 'KABANA 6H'; 'M2' was released as 'KABANA 7H' in 2014. 'KABANA 6H' was named 'Kiwangaazi' in the local language (Luganda) by farmers who participated in the on-farm evaluation studies. 'Kiwangaazi' literally means ''long lasting'' (Nowankunda et al. 2015). The 'Kiwangaazi' variety has been promoted countrywide and, most importantly, introduced in the northern part of the country—originally not a banana-growing area—thus capturing a unique market niche for the variety.

The gender-differentiated preferences have led breeding efforts to refocus on integrating traits that meet men and women's specific needs during characterization and prioritization of new *matooke* varieties. A study supported by the Gender-Responsive Researchers Equipped for Agricultural Transformation project was carried out to identify and prioritize trait preferences of men and women that shape acceptability of cooking banana varieties by value chain actors in central Uganda. The study mainly focused on central Uganda, where adoption of the released varieties has been reported to be low. The findings revealed that various attributes drive acceptability of *matooke* by men and women end-users, thus corroborating the results reported in the present case study. The attributes could be categorized into those that enhance production traits associated with the food quality and those associated with the marketability of bananas. Overall, the taste of the food of a cooking banana variety was identified as the most important trait for both men and women and highly determines acceptability (Ssali et al. 2017). It was evident that adult consumers cannot compromise on the "taste of *matooke*." For instance, on 27 January 2017, a male key informant in Dekwa Village, Namaliga Parish, Kimmenyedde Sub-county, Mukono District, commented:

> The improved bananas are negatively perceived because of their taste and flavor. A new variety with a big bunch but not tasty will not be accepted. In Buganda, we are very sensitive to taste of *matooke* and mostly treasure the taste and flavor. We normally say "ndiirabutafa" (meaning "am only eating to survive").

However, taste was also regarded as a combination of many other quality attributes, including flavor, appearance, and softness of the food when cooked. As reported by a male farmer during group interviews on 26 January 2017, in Kimenyedde Sub-county, Mukono District: "Before I even know the taste of the food the flavor and color will raise my anticipation of a good taste."

Although most of the traits were equally appreciated by both men and women, there was greater appreciation for production and market-related traits like tolerance to drought, tolerance to poor soils, bunch size, maturity period, and shelf life by men. On the other hand, women more greatly appreciated food quality traits like the flavor and the color of the food when cooked.

To make the banana-breeding process more responsive to end-users' needs and preferences, there has been a change in the sequencing of attribute selection. Now, new *matooke* hybrids are evaluated and selected for sensory attributes before technical traits such as yield and pest and disease resistance. Also, women panelists are involved in the preparation of the samples for sensory evaluation to capture processing attributes like ease of peeling and stickiness of the sap after peeling. Efforts are also being undertaken to involve more actors (e.g., consumers and traders) in the evaluation and selection process.

Conclusion and Implications for Breeding

Quality attributes—especially taste of food for cooking banana—is the most important trait for both men and women and determine whether or not a banana variety will be adopted. Future breeding efforts could focus on defining the compound(s) that determine the taste of cooking banana varieties so as to guide in the selection of parents and lines at the different stages of the breeding pipeline. Further, this research demonstrated the need for gender responsiveness at the various stages of the process. Changes in the breeding process to allow for integration of the gender-specific preferences are expected to serve as a motivating factor to enhance uptake by end-users. It is anticipated that adopting these high-yielding, pest- and disease-resistant banana hybrids with desirable attributes will increase banana productivity, leading to increased food security, well-being, and improved livelihoods. There are prospects for the application of genomic selection in *matooke* breeding; however, tools like quantitative trait locus mapping and models for predicting the breeding value of the parents are under development.

Lessons Learned

In line with other adoption studies, we have learned that quality attributes play an important role in the selection and eventual adoption of banana hybrid varieties by men and women. Although men tend to look at yield-related attributes, the quality attributes stimulate demand and market for banana varieties. Banana-breeding efforts therefore need to be more gender responsive with the goal of developing new varieties for well-defined target groups and acceptability by actors along the value chain. We recommend a stepwise selection criteria for future banana-breeding efforts. This approach begins with selecting *matooke* for food quality-related traits like taste, flavor, texture, and food appearance; followed by production- or agronomic-related traits like resistance to pest and diseases, tolerance to drought and to poor soils, maturity period, and sucker production; and finally, a long shelf life to ensure market uptake. Such a process is likely to guarantee higher adoption levels among the end-users, resulting in higher productivity and ultimately impacting household food and income security.

Recommendations

Participatory on-farm evaluation and selection are the initial stage for the farmers to interact with banana hybrids. Involving both men and women in this process is important in identifying their needs and preferences; but the crux of the matter is to tailor the breeding pipeline to meet these needs and preferences. Subsequent, participatory on-farm trials should be conducted concurrently with trait discovery studies so that as the needs and preferences are identified, they can be converted into traits to be incorporated into the breeding pipeline.

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Involving women farmers in variety evaluations of a "men's crop": Consequences for the sorghum breeding strategy and farmer empowerment in Mali

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Introduction: State of Sorghum Breeding in Mali, 1996–2005

Malian farmers view sorghum first and foremost as a food crop. Although the crop is valued for other uses like forage for livestock or the stems for construction, these uses alone are not sufficient to justify its production. Sorghum, as an indigenous crop in Mali, had countless generations of farmers contributing to its domestication, and it continues to be an integral part of life and culture today. Sorghum is generally considered as a "men's crop" in Mali and West Africa (Weltzien et al. 2006), since men are typically responsible for sustaining the family with the basic staple cereals used to cook the main meals.

The many sorghum varieties cultivated by farmers indicate how they make targeted use of varietal diversity. Each household typically cultivates two or more varieties, and often more than 20 varieties are cultivated within a village (Siart 2008). Despite farmers' extensive use and management of varietal diversity, their adoption of newly bred sorghum varieties has been relatively low in Mali. Adoption rates in the 1990s were found to be approximately 20% for varieties derived from reselections within landrace varieties, and only about 5% for the so called "second generation" varieties bred for intensified production using more exotic germplasm (Yapi et al. 2000). The better grain quality of landrace-derived varieties for food was found to be one of the main reasons why farmers adopted them more frequently than second generation varieties. Their better adaptation to the farmers' environmental conditions was another frequently stated reason. In fact, low soil fertility was mentioned as one of the major constraints to adoption of new varieties (Yapi et al. 2000). Unfortunately, this study did not mention whether women were included in the interviews of more than 500 farmers, nor did it present any sex-disaggregated results.

Responding to the need for diversity of varieties and to ensure that newly bred varieties possess good food quality and adaptation to farmers' conditions, as called for by Yapi et al. (2000), efforts to involve farmers in the breeding process were reinforced. Farmers' input was obtained by (1) establishing a network of farmer organizations engaged in on-farm testing of new experimental varieties with farmer-managed trials—that is, larger 32 test-plot replicated trials and smaller unreplicated "adaptation trials" with five plots (Weltzien et al. 2006); (2) conducting annual feedback and planning sessions with collaborating farmers to share the previous seasons' results and plan the next seasons' activities; and (3) initiating postharvest culinary tests for food acceptability of the test varieties identified by the participating farmers to be the most promising.

Farmer input at this time was strongly representative of men's points of view, both through discussions and the direct evaluations of breeding materials conducted only by men. This reflected both men's greater access to land for trials and the researchers' understanding that sorghum was a "men's crop." Women were invited and participated in visual evaluations of the test varieties, but the open discussions were less conducive for eliciting women's specific views since older men dominated and women do not easily speak up in the presence of men. Although the grain processing and cooking for the culinary tests were done exclusively by women, the observations targeted at this time were varietal acceptability for food quality (color, taste, and consistency of prepared food, all gender differentiated), but quantitative data were not taken on the grain desirability for the processing activities done by the women.

Furthermore, the role and responsibilities of women in sorghum production in Mali had not been examined due both to the understanding that sorghum was a "men's crop" as well as the human and resource limitations of the sorghum improvement team in Mali. A social sciences student initiated this research, contributing gender research skills to the team. On the basis of this specific study, the sorghum breeding team implemented a series of changes in the procedures used to select and evaluate experimental sorghum varieties. These changes (i.e., the results and insights with respect to selection criteria, variety choice, and gender responsiveness) are presented and discussed in a separate section. Overall conclusions are presented before drawing general lessons learned and describing specific tools used.

Targeted Study of Women's Sorghum Production

FGDs were conducted with 5–20 women in six villages in each of two study areas in Mali, Mandé and Dioila. An additional 86 individual interviews of women of widely differing ages were conducted to better understand what role sorghum production plays for women, and what sorghum production constraints may be specific to women (van den Broek 2007). The participants for the study were chosen from families participating in the trials, as well as other women interested in discussing seed-related issues.

The FGDs revealed that most women in both study areas often cultivated sorghum. They most frequently grew sorghum either as an intercrop in their individual groundnut fields or as a sole crop cultivated by a group of women. They produced sorghum for (1) preparation of meals not covered by the men's stock of grain—in particular, afternoon meals for young children—but also for adults during periods of field work, mostly during the hungry season, and (2) for sale in the market to generate income (Figure 3.3.3). These uses thus differed from those of the men's production, which was predominantly for the main family meals, with only small portions generally being sold for cash.

The fields allocated for staple food-grain production within a village were typically under older men's management along traditional land-use rights regarding family lineages of the heads of households. Fields that women cultivate were assigned separately and were often less fertile. Over 50% of women interviewed in the Dioila area indicated that they received fields that were less fertile than those received by men (van den Broek 2007). Furthermore, women's access to soil amendments was much more restricted. Women did not even have access to manure from their own animals, as it is reserved for family fields for staple food production. Their options for purchasing fertilizer were also limited—for example, the parastatal cotton company was a major supplier of fertilizer and input credit, but these were accessed only by cotton producers, mostly men.

Women farmers indicated having to wait for the family oxen to plow their fields until after the family cereal and cotton fields have been prepared, particularly in the Dioila region where animal traction is extensively used. More weed problems and lower yield expectations were indicated as consequences of the delays in sowing of women's fields.

Sorghum seed that women use for sowing their fields typically comes from their family members and, to some extent, their own grain production. Discussions with women, however, led to the revelation that they had almost no knowledge about new varieties being tested in on-farm trials in their villages and that their access to seeds of these new varieties was not assured. Some women had not even heard about the ongoing trials, even when their male household members had conducted them. Only in one of the 12 villages conducting variety trials did some women mention the name of a variety introduced through the farmer participatory activities.

This study therefore provided insights into the importance and specific uses of sorghum produced by women. It revealed that participatory variety evaluations in the women's village, even by their own family, was of limited help for their access and involvement with new seeds. These insights provided the justification for making extra, explicit efforts to involve women in the participatory sorghum variety evaluation and seed production activities in Mali and other West Africa countries.

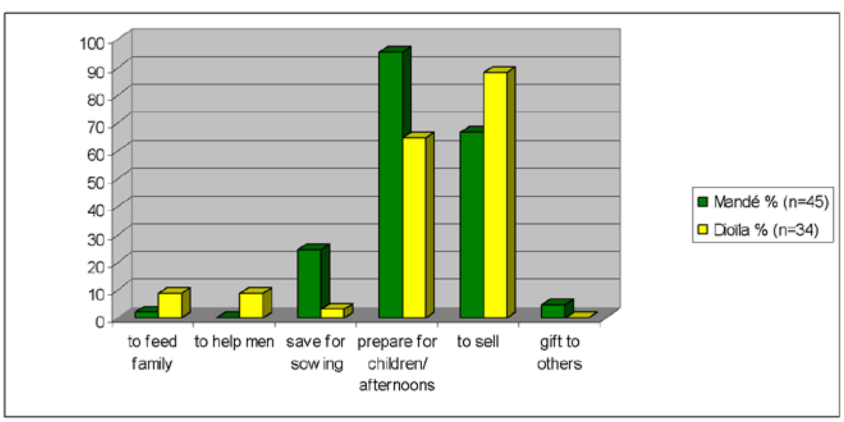

Figure 3.3.3 Specific uses of the sorghum grain produced by women, expressed as percent of women mentioning each use within each study area (van den Broek 2007).

Changes Made in Participatory Breeding Procedures to Enable Women to Better Contribute and Benefit

Changing the procedures for early generation yield trials

The procedure for farmer-participatory variety evaluations (Weltzien et al. 2006) was examined for ways to strengthen women's inclusion by considering participatory breeding methods used in Burkina Faso (vom Brocke et al. 2010) and the previous experiences in Mali of how women's effective participation may have been constrained. One modification was that women were not only invited as before, but they were informed from the onset of discussions that their contributions would result in options for variety trials that they themselves could conduct.

Another change was that, after the routine briefing of farmers about the trial field management and their first walk-through visit of the plots, separate men and women's groups were formed. The aim was to facilitate discussions to identify which traits should be scored (i.e., for which traits of importance for adaptation and adoption did the test entries show differences). These women- and men-only discussions also enabled the team to probe for understanding the significance of specific traits mentioned, particularly regarding gender roles and responsibilities, cropping system changes, and opportunities.

The men and women's groups then came together to present the traits that each identified, with plenary discussion and negotiation to reach a common agreement about which three traits would be used for visual evaluation by all participants. Subsequently, the exact wording was briefly discussed for defining how each trait would be scored using the standard five-level system: 5 represented the best expression, and 1 the worst.

Following these agreements, small groups of four to five farmers, mostly composed only of men or women, scored each plot for the three agreed traits as well as overall appreciation. Each small group was accompanied by a facilitator who could note the scores agreed by the group, as well as any specific issues that the members discussed to arrive at a decision for a plot score.

The final step in the procedure for these pre-harvest evaluation involved individual farmers scoring each plot, using slips of different colored paper to "vote" their score. These paper slips—white for favorable, yellow for warrants a second look, and red for reject—were also marked to identify the voter's sex.

The procedure for post-harvest culinary evaluations of promising participatory-trial entries was also modified to include grain processing traits of importance for women and traits for which women are the experts. The details of these quantitative measurements and the implications of using the revised culinary test methods are reported in a separate case study in this volume.

Adapting the design of farmer-managed variety trials to women's needs and capacities

Consultation with women farmer groups revealed that the established adaptation trials, although unreplicated with only five entries, were still too big for many women to accommodate in their sorghum fields. Also, the test plots with solid (sole crop) sorghum were less interesting for women who cultivated sorghum as an intercrop in their groundnut fields.

The breeding team therefore modified the design of these trials to offer three entry trials in which women could compare just two new varieties to their own check variety. Also, the sorghum test plots could be sown with widely spaced rows and groundnut intercropped between the sorghum rows.

A subsequent modification for both the 3- and 5-entries trials enabled the test varieties to be evaluated under two types of crop management. By lengthening the rows and splitting each plot in two, half of the plot could be grown with an improved management practice and the other half under the farmers' normal practice. The most commonly chosen factor for the improved management treatment was fertilizer application, although women also chose application of wood ash as a soil amendment and different stand densities.

Adapting the annual planning procedures to facilitate women's contributions

The breeding team put in place the following changes for planning and implementing farmer-collaborative activities so as to improve women's awareness of the ongoing trials and increase their access to seed of the new varieties:

- Variety trials would only be conducted in villages where at least four women were interested and ready to conduct their own trials (3- or 5-entries adaptation trials).
- Women would be welcomed to produce seed of new varieties if they could sow at least 0.5-ha production plots.
- A female facilitator was identified to coordinate actions jointly with a male facilitator where the breeding program worked with volunteer village facilitators for planning and coordinating activities.

Results and Implications for Breeding by Changing Procedures to Strengthen Women's Inclusion in Collaborative Varietal Evaluation and Seed Activities

Learning and action on major soil fertility constraints prompted by women's variety testing

Women's interest in the option of conducting their own small, 3-entry trial, intercropped with groundnut, was astounding. By 2009, 32 villages with 125 participating women conducted these trials. Soil analysis of women and men's trial fields in the same villages confirmed that low soil fertility was a major constraint. Sorghum experiences phosphorous (P) deficiency below a threshold of 7–10 mg/kg plant available soil P (Bray-1P) content (Doumbia et al. 1993), yet the men's fields averaged only 7.4 mg/ kg and women's fields were even lower, averaging 5.2 mg/kg. More important was the actual distribution, with men's fields straddling the threshold level; but most all of the women's fields were below it, with the majority at the very lowest level (Figure 3.3.4). Therefore, sorghum adaptation to P-deficient soils requires breeders' attention for serving the majority of smallholder farmers, especially women farmers.

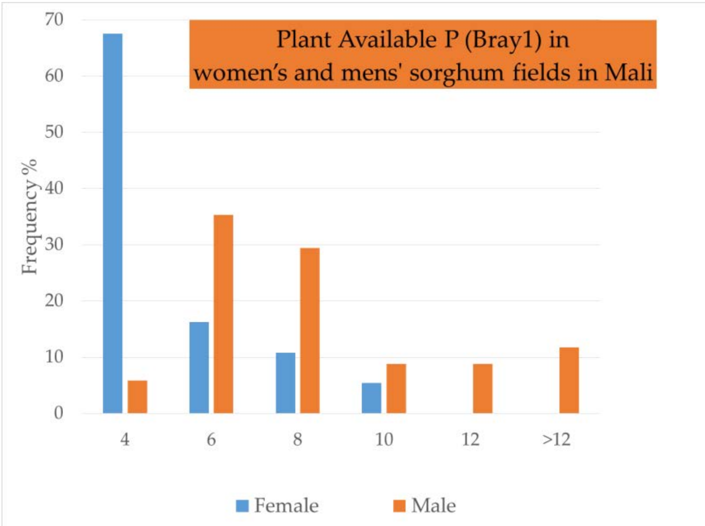

Figure 3.3.4 Frequency distribution of 35 women's fields (blue) and 36 men's fields (orange) for plant available (Bray1) phosphorous (mg/kg) levels in Mali, 2009.

The 3- and 5-entries variety trials conducted by women in 2010 across three major production zones (Mande, Dioila, Koutiala) showed that (1) women experimenting with fertilizer application or even simply applying ash from cooking fires could obtain major yield increases (Figure 3.3.5), and (2) the rank order of varieties for yield level were fairly comparable between the farmer-practice and intensified management. Although results are only shown from Siby village in Mandé (Figure 3.3.5), similar trends were obtained across the three regions (unpublished data).

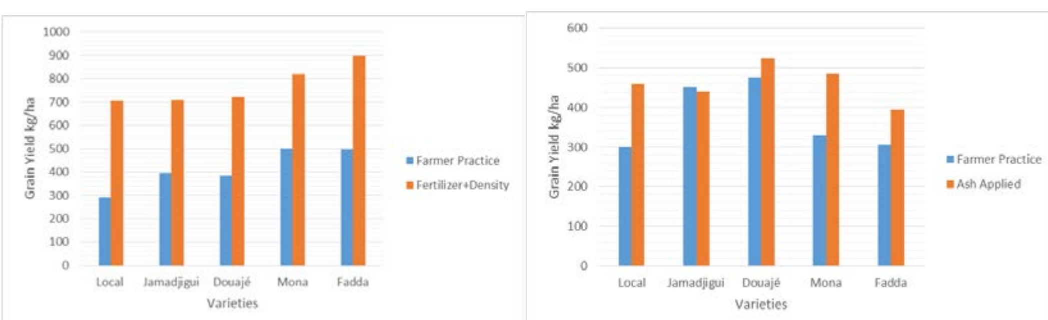

Figure 3.3.5 Mean grain yields of the farmer's own local variety ('Doronkonikalan') and four test varieties averaged over women's trials with split agronomic practices, the farmer's own and improved practices (*left*: four trials with application of 100 kg/ha di-ammonium phosphate and sowing higher plant density; *right*: two trials with application of wood ash) in the village of Siby, Mali, 2010.

Variety trait preferences obtained with modified evaluation procedures

The use of the modified procedures in all village-level variety trial evaluations enabled amassing a large pool of data from more than 130 group evaluations (one third women, half men, and remainder mixed) conducted over a 5-year period (2009–2013) across the three target zones in Mali. The frequency with which farmers chose aspects of early maturity, productivity, and fodder quality as criteria for evaluating varietal differences indicates the general importance of these traits. Analysis of group evaluation scores indicated that the farmers effectively differentiated among varieties for the traits under evaluation (Variety in Table 3.2.3). The very limited significant Group x Variety interaction points to considerable concurrence between women and men in how they scored the diverse varieties.

The groups' overall appreciation of a plot, based on all traits of importance, whether scored or unscored and their perceived relative importance, was noted using a 5-point scale. The absence of Group x Variety interaction for overall appreciation indicates that no major gender differences within villages were detected for overall variety appreciation (Table 3.3.1). A more detailed examination of mean overall appreciation scores for specific varieties, however, indicates that women better used the entire scoring range, scoring some varieties extremely highly and other at the bottom, whereas men gave more intermediate scores (Figure 3.3.6).

Table 3.3.1 Frequency of specific traits being chosen by farmers for evaluations and number of cases of significance for varietal, group, and variety by group interaction variance within evaluations in individual villages and year

Evaluation Trait	Number of Occurrences by Village and Year			
	Trait Evaluated	Variety ($p<0.05$)	Group ($p<0.05$)	Variety x Group ($p<0.05$)
Early maturity	12	12	1	1
Productivity	10	9	3	0
Forage quality	9	9	4	1
Lodging	5	5	3	1
Overall appreciation	11	10	2	0

Women gave higher appreciation scores to most hybrid varieties and lower scores for varieties with serious weaknesses such as 'Massa-Hybrid' (poor threshability) and 'Bobi' (too late). The women's higher appreciation of a series of extra early-maturing varieties (clockwise from Sawaba to Yebele) suggests that women appreciated extremely early maturity. The mixed groups rated these varieties similarly to men-only groups, suggesting that women's preferences were weakly considered in the context of mixed groups.

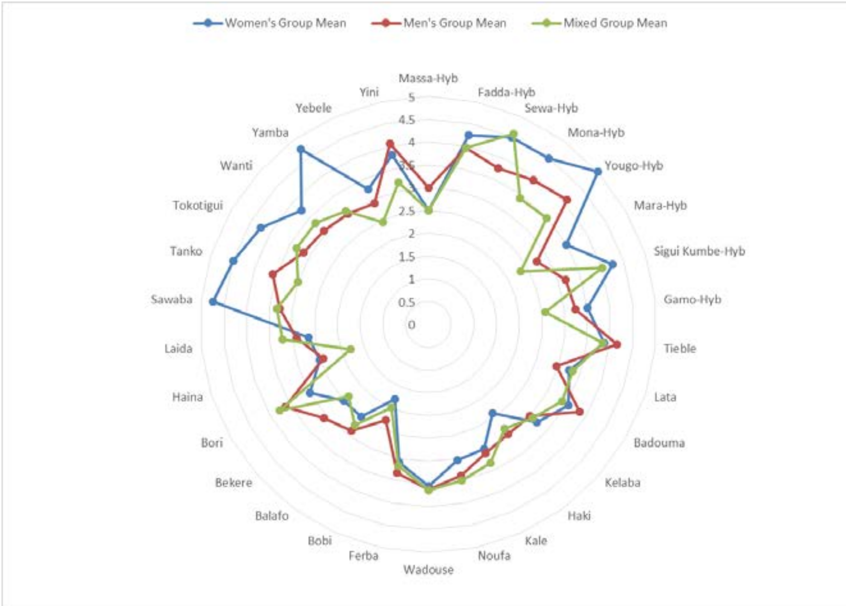

Figure 3.3.6 Global appreciation scores for 30 sorghum varieties and hybrids (Hyb) in on-farm tests averaged over women's, men's, and mixed evaluation groups in trials conducted over three zones in Mali, 2009–2013.

Contribution of women and men's participatory testing to varietal diversity

The number of improved varieties cultivated in villages of the Dioila region of Mali (Table 3.3.2) was examined by a survey in 2005 (approximately 65 extended family farm households) (Siart 2008), and a subsequent follow-up survey of the same households in 2011 (Somé 2011). These surveys indicated that tester villages in which variety evaluation trials were conducted since approximately 2001 had higher adoption of new improved varieties than in control villages of similar socioeconomic status but where no variety testing was conducted (Table 3.3.2). The study also found that the number of improved varieties cultivated in tester villages increased considerably in 2011, 4 years after women started to conduct their own varietal trials. The impact of women's participation in variety testing and their practice of sharing seed on village level variety adoption warrant further study.

Table 3.3.2 Number of improved sorghum varieties cultivated in 2005 and 2011 by villages with differing histories of participation in sorghum variety testing in the Dioila region of Mali (Somé 2011)

History of Variety Testing	Village Name	2005	2011
Participating	Banco	1	3
	Magnambougou	1	2
	Wakoro	2	5
No participation	Kanfara	0	1
	Senon	0	0

Changes in women's activities following engagement in variety testing

The level and diversity of women's activities substantially increased after women began conducting their own variety trials and participating more fully in varietal evaluations and planning meetings. Several women's groups began large-scale commercial production and sale of seed, first of new sorghum varieties and thereafter of groundnut seed. Women's participation thus helped them to diversify their commercial activities, either directly producing the new varieties as in Magnambougou (Dioila), where women started to grow sorghum after they learned about the new variety 'Soumba' and that it is easy to commercialize, or by producing seed. Some women's groups and individual members, on their own initiative, promoted new varieties they were particularly excited about. For example, the president of one women's group used her field as a demonstration plot for the new sorghum hybrid 'Pablo', and invited all household heads to visit her field to see for themselves the variety she believed offered an option for improving income and food security in the village. This represents a major change from the situation before, when women were not aware of which new varieties were available in their village, or even that variety trials were being conducted by their own family.

Conclusions and Implications for Breeding

Importance of women's production of sorghum

The revelation and detailed understandings of women's engagement in sorghum production and its importance for child nutrition and income, derived from in-depth qualitative and quantitative research coupled with long-term engagement, gave impetus to explicit efforts and methods to listen to women's concerns and facilitate their own experimentation. Implementing more gender-responsive participatory breeding appears to have empowered women to engage in various seed-related activities, definitely increased their access to new varieties, and likely contributed to increasing the diversity of improved varieties cultivated in their villages. Women's fuller involvement in the participatory breeding activities have also led to several major changes in the breeding program as detailed below.

Addressing grain-quality traits

A fundamental long-term change of the breeding program is the inclusion of selection criteria to ensure that newly bred varieties have desirable grain quality. Women's involvement in trial evaluations and grain processing procedures led to understandings of how grain decortication losses differ substantially among test varieties, and that these losses can reduce or nullify the benefits of increased harvests. The attention to grain quality of new varieties should additionally help to minimize grain storage losses from storage pests, and reduce the time and effort women spend on grain processing.

Women with expertise in observing grain quality are now invited to the research station to score grain qualities of early generation material during the selection process. The genetic gains and impact attained by the breeding program will now likely be higher due to better focus on breeding materials and "finished varieties" that are more acceptable and useful to farmers.

A team of nutritionists working with women participating in varietal trials further revealed the important role of sorghum and pearl millet for micronutrient nutrition of children. Working with these women they developed a new method for producing whole-grain sorghum flour for preparing *tô* (staple dish) and children's weaning foods with elevated iron and zinc. The new method was additionally appreciated by women due to saving labor and producing foods with desirable taste and consistency (Bauchspies et al. 2017).

Adaptation to low soil fertility

The revelation that most farmers, men and especially women, produce sorghum under low soil-P conditions calls for breeding programs in Mali and all of West Africa to address this issue to serve the majority of sorghum farmers. The sorghum programs of the Institut d'Economie Rural and the International Crops Research Institute for the Semi-Arid Tropics in Mali jointly explored diverse approaches to breeding varieties with better performance under P-limited conditions (Leiser et al. 2012a,b; 2015a,b). As a consequence of those findings, the sorghum-breeding programs in Mali now grow all early generation material under low-P conditions in fields managed specifically for this purpose. Routine yield trials are now conducted under both high- and low-P conditions.

Hearing women's voices

Strengthened women's participation in trial evaluations through separate discussion of their priority traits for evaluation, followed by facilitated plenary discussion of all women and men to reach consensus, gives weight to women's propositions and opinions. Village-level evaluations, done by men and women, now better consider traits suggested by women. The breeders' and farmers' varietal choices therefore take into account traits of importance to women at an earlier stage when greater diversity is still available. One consequence of taking women's selection criteria and varietal choice as seriously as those of men was stronger inclusion of women's preferred varieties for seed production by the village cooperatives. Women were also empowered to diversify their economic activities, including large-scale production and commercialization of sorghum and groundnut seed.

Tool Box

Practical approaches for researcher–farmer collaboration in priority setting and characterization of farmers' production systems, goals, and trait preferences are detailed in a handbook written for applied field work (Christinck et al. 2005). Methods and tools specifically for setting up and implementing breeding activities with farmers are detailed in one section of the handbook (Weltzien et al. 2005). The handbook also provides case studies with practical experiences, links, and contacts of interest for plant breeders, persons involved in sustainable seed system development, biodiversity, education, training, and extension.

Tools for conducting variety evaluations, including farmers' identification of evaluation criteria, are described based on applied work in Burkina Faso (vom Brocke et al. 2010) and Mali (Weltzien et al. 2006; Weltzien and Christinck 2008). The method by which farmers vote their overall appreciation for test varieties, mentioned in the Results section above, involved preparing small slips of white, yellow, and red paper and attaching one large envelope with the plot and entry identification to each test plot evaluated as a "ballot box." Each participating farmer is given an envelope containing all colors, with instructions to cast a vote for each plot by placing a white paper slip if he/she thinks the plot is clearly of interest for future cultivation, a yellow slip if the test entry warrants being looked at again, and a red slip if it should be rejected. The colors correspond to the popular yellow and red cards for football/soccer, with yellow cautionary before deleting, and red is an "out." Paper slips used by women are all marked with a specific sign, such as a line or cross, and envelopes with these slips are specially marked and distributed to women at the time of voting. The ballot box envelopes are recovered after voting and saved. The votes are tallied to produce the global appreciation score by adding the total number of votes cast, giving one point for each white vote, and a half point for each yellow vote, summing all points, dividing by the number of total votes, and multiplying by 100. Thus, the best possible overall appreciation score is 100 and the worst is 0.

An approach that goes beyond formal discussions and data gathering is simply taking time to discuss with women and men farmers, researchers, or anyone who understands the "pulse" of the community. Taking such opportunities can provide valuable insights that are not captured in the data gathered or the questions that were previously framed.

Certain practices can be useful, not only for "hearing" women's voices better but also for actually empowering women. Establishing the rule (or norm) that participatory variety testing will be conducted in a village only if at least four women conduct their own trials is one example. This practice both strengthened women's roles in the participatory activities and resulted in positive benefits in how they were regarded in the village.

Another empowering practice is to conduct the initial discussions with women and men farmers separately when identifying evaluation criteria or planning activities. The initial discussion outcomes are then presented to the whole group and, in the case of joint action, facilitation is provided to arrive at a position acceptable to all. This approach results in greater transparency and understanding for all. Women farmers' engagement in new activities such as conducting their own variety evaluations or initiating seed production has clearly increased following involvement in such processes. Men have also recognized that having women's inputs earlier in the process is beneficial and helps arrive at decisions that are best for the family (Box 3.3.1).

Finally, long-term engagement and collaborations with local partners has fostered an important element of trust and rapport between farmers and members of the development and research communities that is absolutely necessary for honest dialogue and joint learning in the context of environmental and social diversity and deep cultural roots. Long-term engagement has been a key for the advances made to date. The sorghum-breeding programs in Mali have now developed a collaborative network with farmer organizations to operate on a regional scale. The interest to maintain and strengthen this approach to operate at scale and create value with and for the numerous smallholder farmers exists, accompanied with hopes of longer-sighted support and continued capacity building for all actors to continue the process.

Box 3.3.1 Dedicating resources to understand gender roles and ambitions from the beginning

We found that specific research efforts to understand gender roles, responsibilities and ambitions in any crop context, even for those considered to be "men's crops," can have wide ranging consequences for gender responsive research and impact. Seeking such understanding appears to require explicit efforts independent of simply having women participating in the breeding activities. Also once such insights are gained, participatory approaches for continuously engaging with women are vital for refining understandings of their knowledge, their evolving roles and needs, and for jointly identifying new opportunities that lead to benefits for the whole family.

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3.4 Seed Production and Distribution

Gendered Seed: From Variety Selection to Control over Seed

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Introduction

Seed security is a key component of food security because seed is the first link in the food value chain (Galiè 2013c; World Bank, FAO, and IFAD 2009). Access to adequate seed typically is the main guarantor of adequate nourishment at the farm household level (Santarius and Sachs 2007), and the secure access of women to adequate seed is particularly critical in household food provisioning (Jiggins 2011). The questions of "whose preferences and needs" are taken into account in seed improvement and "who benefits from seed development" are important research issues that are consequential for both food security and gender equity outcomes. However, there has been a general failure to translate into practice the recognition that gender inequality is an important issue in seed technology development and adoption (Ransom and Bain 2011). The improvement of crop varieties through plant breeding often is considered mainly in terms of its aim to produce "technical outputs" (i.e., improved crop varieties that yield more than local varieties). This raises concerns about the extent to which plant breeding can produce seed that matches the actual demands, needs, and local market opportunities of women and men smallholder farmers, in diverse backgrounds and contexts (affected by, for example, access to inputs, machinery, labor, credit, information, etc.) and that takes into account their life circumstances (e.g., age, ability to work off-farm, mobility, etc.). It also raises concerns about the effectiveness of plant breeding in providing new varieties that are adopted by farmers without addressing issues of access to and control of seed at household and community levels as affected by seed governance—the customary rules, formal regulations, and policies at national and international levels that affect individuals' access to seed.

PPB for crop improvement is a science-based procedure in which professional plant breeders and researchers from various disciplines collaborate with farmers to produce locally adapted varieties that meet farmers' needs, priorities, and local market opportunities (Almekinders and Hardon 2006). The PPB program was active in Syria between 1996 and 2012, coordinated by the International Centre for Agricultural Research in the Dry Areas (ICARDA) in collaboration, from 2003 to 2008, with the General Commission for Scientific and Agricultural Research (the Syrian national research institution for breeding) and with extension staff (who are present only in the larger villages). The program had proven successful particularly in reaching poor farmers from marginal environments who have traditionally been overlooked by technology development (Ceccarelli et al. 2013). Moreover, PPB was shown to address some of the shortcomings of the seed system in Syria. By collaborating with farmers to grow and evaluate trials in their fields and to multiply the varieties[7] they selected, PPB shortened the time it took to formally release a new variety (from about 15 years to 7–8 years) (World Development Report 2008) and focused on varieties relevant to farmers (only few releases through the official system in Syria had been adopted by farmers). Finally, PPB had made relevant seed available and accessible to farmers: even when new, officially released varieties were acceptable to farmers in marginal environments, the seed was often not available in such areas or it was too expensive. Because of its ability to address the interests of several and diverse farmers and deliver relevant seed to them, PPB is a promising approach to address gendered preferences and constraints. Achieving a gender-balanced participation of farmers in Syria was particularly relevant, given the increasing feminization of agricultural labor (Abdelali-Martini et al. 2003). Between 1996 and 2006, however, the PPB program in Syria had not successfully involved women along with the men; only male farmers were involved. In 2006 a gender expert was involved in PPB to develop a gender-responsive approach and achieve a gender-balanced participation. The experience of developing and implementing this approach is described in this case study.

Background

The PPB program in Syria initially involved farmers in the early stages (third generation) of breeding. Male farmers from 24 villages (in 2005) were recruited, in a range of marginal areas, typically those frequently affected by droughts and resulting crop losses. The program focused mainly on barley, the major feed crop, and winter cereal, a major source of income for small-scale resource-poor farmers and practically the only crop that produced a worthwhile yield in the more marginal areas. The program proceeded as follows. ICARDA scientists made crosses (using diverse parents including landraces, wild relatives, and modern germplasm), taking into account the trait priorities the farmers had mentioned when selecting their preferences, and multiplied the seed for two generations on the research station. The scientists analyzed, quantitatively and qualitatively, the traits and stored electronic copies of the information. The farmers were involved in PPB from the first yield trials with F_3 bulks (thereafter referred to as *varieties*). Farmers from the same village could have two roles: some farmers managed the trials of the varieties supplied by ICARDA in their fields, decided breeding priorities, and selected their preferred varieties. Other farmers were involved only in selecting their preferred varieties from among those grown by the first group of farmers. After 4 years of testing and selection, both groups decided which varieties to adopt and gave these varieties a name (by that time they were F_6 bulks). Some farmers also were involved in seed multiplication and diffusion in their districts. Each year the farmers grew the varieties they had selected in the previous years as well as new varieties provided by ICARDA, in a cyclical process. The PPB program had consistently delivered well-adapted new barley varieties that offered higher performance than the best comparison seeds in the areas where it had operated (Ceccarelli et al. 2007).

Yet despite the program's efforts to include women in its breeding activities up until 2006, only men had been involved. Although scattered, evidence from Syria was that women played key roles in agriculture providing a substantial share of the labor force as family unpaid or off-farm daily laborers (Abdelali-Martini

[7] The barley PPB program worked on populations, referred to here as *varieties,* as farmers were used to calling them.

2003). Women were also in charge of food preparation for the household. These roles, however, were not visible because gender norms generally discouraged women from taking part in public activities, interacting with unrelated men, and showing their contribution to household productive activities (men only were considered responsible for food provision). A gender expert with a background in anthropology was brought into the team of breeders to assess the interest of women farmers in PPB, increase the gender balance of the farmers involved in the PPB program, and increase the program's responsiveness to gender dynamics. The expert also set out to assess how participation in the program would influence changes in the empowerment of the newly involved women. In 2006 the first activity specifically aimed at involving Syrian women farmers was organized: a farmer exchange initiative brought women and men farmers involved in PPB in Jordan to PPB sites in Syria. As a result, the Syrian women expressed an interest in participating in the program, and a series of activities were organized over 5 years to facilitate their participation. Seven women from six households in the two villages of Lahetha (Deraa Province in the South) and Souran (Hama Province in the Center) became involved in PPB activities. Five more women from three households in the village of Ajaz (Idlib Province in the North) expressed an interest in participating in PPB and, although collaboration never started, they became involved in the study. All 12 women were involved in intensive interactions with the gender expert to explore changes in indicators of empowerment that they themselves had identified. Finally, the gender expert explored how regimes regulating the governance of seed at regional, national, and local levels affected women's access to seed in their communities and households and, ultimately, their empowerment. These activities ceased in 2011, when the war started and the PPB program was disrupted.

Results

Gendered roles in crop farming and access to resources

In 2006, when asked about the reasons for their absence from the PPB program, the respondent women declared that, in order of importance: (1) they had not heard about PPB; (2) they lacked decision-making opportunities over the family land they were cultivating (and could not decide to host PPB trials); (3) they had assumed that it was the men farmers who were the target of the PPB activities; and (4) they were not interested in barley. These issues were explored in more depth over the following 4 years and in relation to three indicators, respectively: access to resources (information, access to productive resources and seed in particular); recognition (perceptions of the role of women as farmers); and access to opportunities (gendered roles in crop and farm management and ability to participate in PPB activities). Decision-making was a fourth indicator cutting across the previous three. The study started by assessing the gendered roles in the farm of the respondents. These roles along the food value chain varied depending on crops, villages, households, and individual circumstances (e.g., age, marital status, social status). Women were generally more involved in agriculture—and manual activities in particular—than men who had easier access to non-farm jobs. Barley and wheat cultivation was mostly mechanized and outsourced to male daily laborers who were hired with their tractors. Mostly older women and men were involved in barley and wheat cultivation when done manually. Older women were generally in charge of storing the seed preserved in the household. Men and women relied on parallel and complementary systems of information access: women relied on informal channels connected to the family (and women's organizations in Lahetha), whereas men relied on more formal channels (Figure 3.4.1). Generally, women had very limited ownership of land and water, access to quality seed, and decision-making responsibilities about farm management. Men were in charge of sourcing the seed for the household, mostly from other male farmers in the neighboring villages or from more formal channels in urban areas (shops, extension offices, etc.). Women generally relied on their menfolk to get seed but exchanged with other women in their community smaller quantities of varieties with traits complementary to those provided by their menfolk (e.g., they exchanged local varieties of wheat that had better taste than the varieties the men had selected because of higher yields). In almost all cases single women relied on some male relative to support with these "public activities." Women were generally overlooked or undervalued as farmers by both men and women, at the household and community levels. Men typically were considered to be "the farmers" and women to be "only their helpers" (Galiè et al. 2013).

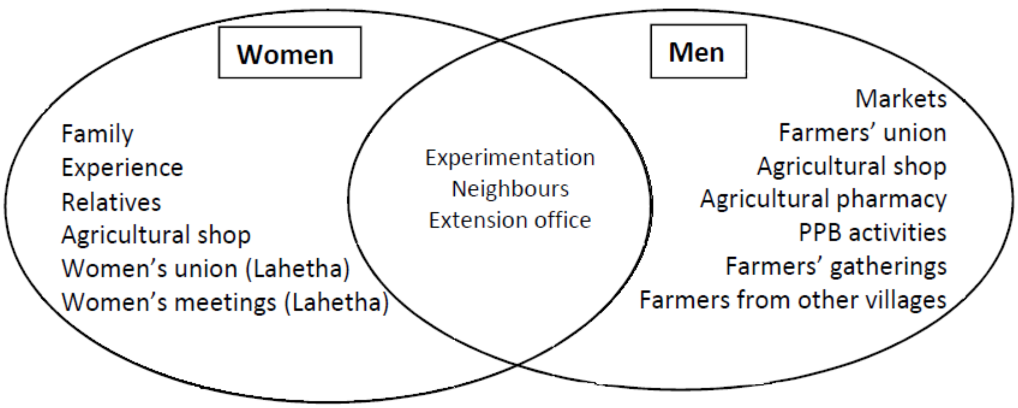

Figure 3.4.1 Sources of information for the respondent women and men.

Gender-responsive PPB

Because both women and men were found to be mostly involved in complementary activities, a gender-balanced participation of farmers in PPB was considered important to improve varietal development and adoption based on the preferences, needs, and knowledge of both women and men farmers. Therefore, the PPB program started adapting its activities to involve the women farmers who had expressed an interest in PPB in order to achieve an equal number of male and female participants in the longer term. Through the gender expert the program actively reached out to the women in the PPB villages and involved the ones interested as trials hosts and evaluators. The program conducted gender-disaggregated variety and trait ranking (see methodology section for details). Some of the traits that the women valued in common with the men included large seed, healthy plants, drought resistance, and color (in some areas dark was preferred to white and vice versa). Some traits that were more important for women than for men, including (1) spike hardness (hard stems were discarded by the women in the three sites because hard stems hurt the hand when hand harvesting and were not palatable for the animals); (2) plant height in Ajaz (short plants could not be machine harvested and hand harvesting was done by women who therefore valued tall plants; (3) stem flexibility (flexible stems with few knots were needed for making baskets that the women in Lahetha sold, and also to ease harvesting because stems that were too fragile broke easily; and (4) flour elasticity, which is necessary to prepare the local bread in Lahetha and a trait difficult to find in the flour available in the market. These traits were important both to those women who used the seed in their household and those who sold it; the latter sold the seed in their village to women customers who had similar demands. These traits that were prioritized by the women were integrated with those prioritized by the men and considered by the breeders when deciding crosses to be made and by men and women farmers when choosing what varieties to grow in the trials of the following year. The PPB program also adjusted trait evaluations to accommodate culinary tests. In 2009 the program also started to include trials with wheat, chickpea, lentil, and cumin because the women had expressed interest in them.

The study found that it was important to include gendered preferences also in cases when women and men performed the same activities. Indeed, gender-based perceptions of “appropriate behaviors” affected the way women and men performed these activities. As a matter of fact, men and older women (above 60) were found to be in charge of seed sales. But because of restraints on women’s ability to interact with unrelated men and in public spaces, women marketed their seed to other women in their village only. Men, on the other hand, had a much wider and diverse reach of customers when selling seed; they sold to male farmers within the village, to neighboring villages, and even to urban customers. Thereby, it might be too simplistic to assume that because women’s involvement in seed purchases or grain marketing on the whole might be limited and parallel to men’s, their trait preferences are not important in crop improvement and development. The findings suggested, on the contrary, that age played a key role in determining who could sell seed among the women and that seed sales were essential sources of income for older women. Also, gender norms determined women’s limited scope in the sale of barley and their preferred female clientele in seed sales, distinguishing their trait needs from those of men who sold to more distant buyers (who might have different quality criteria) and into both formal and informal markets.

To support women’s control over seed, the PPB team ensured that (1) the preferences of both women and men would be taken into account in deciding which crosses to make; (2) all farmers would be involved in naming the selected varieties; and (3) women and men would get access to the seed they had participated in selecting. The team actively intervened during the instances when the participation of women was undermined. For example, one year the women’s fields were declared unfit for hosting the trials, a second year the women’s fields were mistakenly ploughed after planting of PPB seed, and a third year these fields were not planted with PPB seed as had been agreed (Ceccarelli et al. 2012). The program also supported the use by women of program equipment to clean and treat the PPB seed for sale. To increase women’s access to information the program developed and shared visual printed material. It also organized two international exchange visits with other farmers and scientists (e.g., agronomists, breeders) as well as courses in computer skills after delivering some computers to each community.

To enhance women’s visibility as farmers the program organized an international farmers’ conference where women and men presented on their work as farmers, knowledge of crops, and trait preferences (Galiè et al. 2009). The conference set-up was discussed with all farmers to ensure its success. As a result, the conference adopted a story-telling approach to ensure that the illiterate (and women in particular) were not discouraged from public speaking. It gave appropriate importance to the stories shared by organizing a podium for the speakers. Meetings were held before the conference to ensure the women felt comfortable presenting their stories. It arranged for “guarantors” to accompany younger women to the city and avoid compromising their social status (local traditions do not allow young women to travel without a family supervisor).

Impact on empowerment

After 4 years of involvement in PPB, positive changes in the empowerment of women were visible in terms of the recognition of women as farmers by the women themselves, their families, and communities (Galiè et al. 2013). Women’s control over seed increased as a result of women’s decision-making over what varieties to select and grow, and secure access to their preferred PPB seed. Women felt their access to information had increased about the existence of varieties adapted to their environments and needs, agronomic management, and sources of seed. Two women found the PPB seed to provide them with a new opportunity to make a good living through the sale of both the seed and straw. This was particularly important for them, given their limited revenue-generating opportunities in the village. Overall, all women, younger and older, found that participation in PPB had increased their decision-making in the management of the family farm. Younger women, however, faced more constraints in taking part in PPB activities than older women (Galiè et al. 2017). Having more women from the same village involved in PPB also facilitated women’s involvement in project activities.

This study did, however, find that gender-blind seed governance hindered the success in providing varieties that responded to the preferences of women and men and in enhancing women’s empowerment. Gender discrimination at community level (e.g., perceptions that women lacked agricultural knowledge, were unable to travel alone, owned low quality fields, were unable to make decisions of any sort, were not involved in agriculture, were not supposed to contribute to family income) was often leveraged by male farmers to exclude women from the benefits of participating in PPB-related activities. This was particularly discriminating in the case of female heads of households who could not secure their access to the PPB benefits through their menfolk like other women in male-headed households. The intervention of the PPB team was often necessary to ensure that the women could participate in the PPB in equal terms to the men; however, the team lacked a formal reference to back their demand that communities adopt gender-equal processes and outcomes. The lack of an explicit gender lens in international legislation that guarantees the rights of farmers to genetic material was translated in Syria into gender-blind regulations on access to and control over genetic material at national level. Gender-blind national legislation was then operationalized in communities and households in ways that reflected gender-discriminating customary norms that favored men’s control over improved seed, the related benefits, and decision-making.

Conclusions

A gender-sensitive assessment of trait and crop preferences was found in this study to show gendered preferences related to complementary activities that women and men performed (e.g., hand-harvesting, straw handicraft making, and cooking were activities performed by women only that entailed specific traits). The study found that also in cases when women and men were engaged in similar activities, such as the sale of seed and straw, gender norms entailed gendered preferences by affecting the way the activity was performed by each group. For example, women sold only informally to other women in the village, whereas men sold through formal and informal channels to male customers from neighboring villages and urban areas and considered these customers' needs when selecting the varieties. Also, the study found that women's ability to participate in the PPB program was affected by individual circumstances (e.g., a combination of age or marital status; younger women faced more constraints in participating in the program but found in the sale of PPB seed an opportunity to make a living). This latter finding was particularly relevant given that young women's livelihood opportunities in these communities were more limited compared with men. As a result of this evidence, the study found it difficult to establish a priori the rationale for identifying specific groups of farmers (rather than others) to participate in PPB: involving most household members seemed necessary for PPB to develop relevant varieties. As a matter of fact, the study argued that the following farmers needed to be involved in PPB: male and female farmers from the same household (because gender dynamics affected trait preferences of women and men when performing both complementary and same agricultural activities); household members who were involved in cultivating the crops that were relevant to the PPB program (e.g., men who were mostly in charge of growing barley), and also those who were not traditionally involved in growing these crops (e.g., women who were considered to only grow manually cultivated crops) but for whom PPB activities could constitute a new opportunity for a living (such as in one case where barley became the main source of income for two women) and; women and men farmers across age groups (because age could affect gendered variety preferences and opportunities to market PPB seed). The study therefore raised the issue of how much variability in trait preferences and needs PPB could accommodate. We argue here that by including both men and women farmers, PPB could address two major but distinct categories of stakeholders. The benefits of adopting a gender-responsive operationalization of PPB, however, in turn depends on the PPB researchers' ability to shape the PPB process in ways that facilitate the participation of both female and male farmers and to work with their different knowledge, preferences, and needs. Finally, the study shows that to achieve the outcome of increasing the access of women and men farmers to relevant seed, a gender lens needs to be applied to seed governance issues. Specifically, breeding programs need to pay attention to how regimes regulating access to genetic material—seed in particular—impact on actual control over seed of women and men farmers. This is even more so in cases of breeding programs that aim to empower women farmers. Lack of gender-responsive seed legislation at international level may result in gender-blind legislation at national level that, in turn, reinforce existing gender-discriminating patterns at community level that may limit women's control over seed. Finally, the study argues that lack of control by women (and men) over the seed produced through PPB undermines women's empowerment (Galiè et al. 2017).

Lessons Learned

An intervention like PPB brings benefits to farmers and can empower those involved. Gender-responsive PPB is necessary to ensure that these benefits are accessed by both women and men farmers as two broad groups of stakeholders. For this to happen, though, a committed team including breeders and gender scientists needs to tailor existing breeding activities to be gender responsive, develop new strategic activities that address identified gendered constraints, and follow up their implementation to avoid that "normalized gender-discriminating norms" affect their operationalization. Adopting a gender equity of outcomes framework requires a commitment to behavior change from all involved and an intentional engagement to doing things differently. From the study it was also evident that social capital was necessary for the successful involvement of women and men alike in PPB. Participating in PPB activities was easier when women formed a group from the same village than for women in a village where only men were involved. This, and the overall evidence from the study, indicates that a technological intervention such as plant breeding rarely can be disconnected from the local socio-cultural context in which it takes place. It also needs to engage with structural change at the macro level for its achievements to be sustainable. In fact, the study shows how the reproduction of gender norms at community level is reinforced by gender discrimination at macro- and institutional levels through, for example, gender-blind approaches to governance of natural resources. Such arrangements affect how a PPB intervention plays out at community and household levels.

Methods

This study set out to address the main research question: "Can PPB affect the empowerment of the women farmers involved, and if yes, how?" To address this question we first ensured that the PPB would respond to the needs of the involved women in terms of the technologies it developed and the processes it adopted to develop them (mostly detailed above in section 3 and in the last paragraph of this section). The gender expert then assessed qualitatively: changes over selected indicators of empowerment, together with the women respondents (Galiè 2013a), and how regimes regulating seed management at regional, national, and local levels affected the access to and control over the PPB seed by the newly involved women farmers (Galiè 2013c). The first stage of the research was a diagnostic study performed in 2006. The diagnosis consisted of (1) a 3-day meeting between 10 Jordanian and 16 Syrian women farmers to discuss their involvement in the PPB program, and to assess the reason for the absence of Syrian women farmers from the program up until then; and (2) semi-structured interviews with 16 women farmers in Ajaz, Souran, and Lahetha about their involvement in agriculture and their interest in the PPB program. The understanding provided by the diagnostic work shaped the research questions that were explored between 2007 and 2011 using selected participatory rural appraisal methods (Chambers 1992) during women-only group interviews and participant observation with 12 women from 11 households in three villages: Ajaz, Souran, and Lahetha (Table 3.4.1). Seven of them were involved in PPB activities, while 5 (from Ajaz) had expressed an interest in getting involved in PPB but collaboration never started. To assess changes in the selected indicators of empowerment, a gender-sensitive analysis was undertaken with these women on the following topics: intra-household agronomic management, constraints and opportunities in crop cultivation, gendered knowledge and information access, gendered sources of access to and control over seed, and ownership of five social capitals (Galiè 2013a). In addition, seven semi-structured interviews with 24 men were conducted to add gendered nuance to the assessments undertaken with the women. Complementary research activities included participant observation during PPB activities, an international farmers' conference, and two international farmers' exchange visits. Finally, eight key informant interviews with breeders, extension agents, local government officials, and a member of the Food and Agriculture Organization of the United Nations FAO were carried out throughout the study to understand how different regimes regulating the management of seed at regional, national, and local levels affected the access to and control of seed by the women and men farmers involved in the PPB program (Galiè 2013c). Table 3.4.1 provides an overview of the tools and methods utilized between 2006 and 2011 to undertake the study and answer the main research question.

Table 3.4.1 Overview of research activities, methods, and issues explored

Activity	Time	Method	Issue explored
Diagnostic study	2006	Semi-structured interviews	Reasons for absence of women in PPB to that date Interest of the women in PPB Assessment of the respondent women's involvement in farming
First stage of fieldwork	2007-2008	Family structures	Family composition Recognition of women as farmers in the selected households
		Daily and seasonal calendars	Involvement of respondent women in agronomic activities
Second stage of fieldwork	2009	Semi-structured interviews	Factors affecting household crop cultivation practices
		Local maps	Intra-household ownership and use of land and water
		Semi-structured interviews	Household sources of seed Household management of seed Respondent women's access to seed
Third stage of fieldwork	2010	Matrix analysis	Respondent women's perception of intra-household decision-making
		Open discussions	Sources of information Perceptions of 'whose knowledge counts'
		Sustainable Livelihood Framework	Women's ownership of five capitals (social, human, financial, physical and natural)
	2007-2010	Literature review	Seed governance regimes at international and national levels
		Key informant interviews	
Interviews with male farmers	2009	Semi-structured interviews	Intra-household agronomic management Recognition of women as farmers Access to information
PPB activities	Cropping seasons 2006-2010	Participant observation	Gender-based crop and trait preferences
		Variety scoring and trait ranking (in the house)	

In this study on integrating gender into a PPB program, we paid particular attention to eliciting the trait preferences of the newly involved women farmers. Because the PPB already had an effective system in place to assess the preferences of male farmers, the team focused on establishing a gender-responsive system to allow both women and men to assess the trials based on their preferences. To this aim, the women were initially involved in trial scoring and selection days (i.e., days when all farmers walked along the trials hosted by some farmers and scored each plot). Their scores and related traits were discussed in a group setting later in the day. The results of the data analysis would be brought back to the farmers a few days later during a new meeting, when the varieties to be kept for further testing the following year would be identified together with new potential parents for crosses. When the women started to be involved in these evaluation and selection days, the male farmers expressed concerns over women's ability to score the trials properly and the consequences on the final list of selected trials. On the other hand, the women—particularly the young ones—felt that it would be inappropriate for them to attend meetings with unrelated men (because the local norms discourage women from interacting with unrelated men). In 2009, a woman was not able to attend scoring sessions in the field because she was pregnant. To address these constraints the PPB team decided to hold separate variety and trait-ranking sessions and to undertake the ones with the women in the house. Bundles of barley from each trial were collected and numbered. The bundles were compared one to one by each woman and their preferred one was recorded (Figure 3.4.2). Ranking the variety answered the question, which of these varieties would you plant? (rather than which variety do you like most?), because the women argued they may like some varieties much but adopt others based on their prediction of which variety would do better in their field in a given year. Pictures of the variety trials were projected onto the wall to also allow for an assessment of the variety in the field. The traits that each woman considered when selecting their preferred varieties were recorded, and the best three varieties from the previous exercise were then scored vis-à-vis the five most important traits mentioned. This scoring was done by distributing seven (a random, uneven, and fixed number) seeds to each trait across the three varieties. The sum of the stones assigned to each variety across the five top traits showed the variety that best scored and the traits associated to it (Figure 3.4.3). Conducting the evaluation in this manner gave the women time to assess carefully each variety (e.g., by touching it, assessing the roughness of the stem) and to compare each one of them with the others by holding them close to each other (Figure 3.4.4).

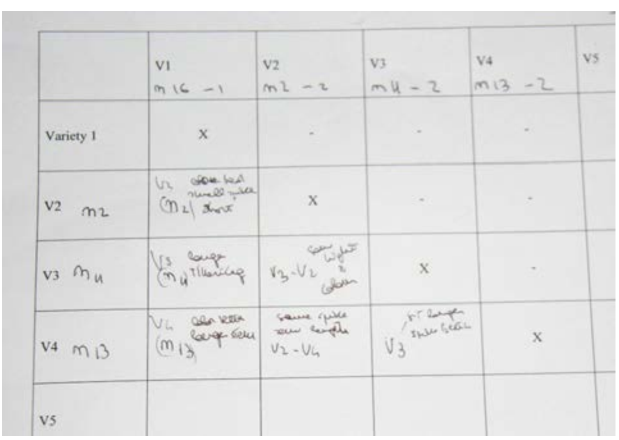

Figure 3.4.2 Variety ranking exercise with identification of prioritized traits.

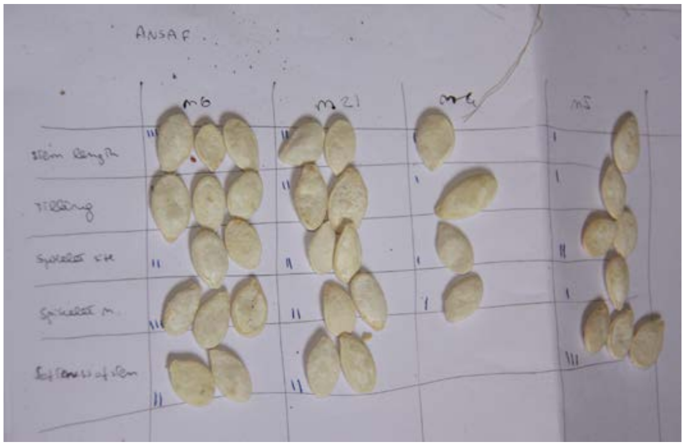

Figure 3.4.3 Traits ranked in relation to best varieties.

Figure 3.4.4 Variety evaluation in the house.

Implications for Breeding

To respond to the gender evidence that emerged from this study, the PPB program adapted its criteria to select farmers to host and evaluate trials; its process to evaluate trials; the traits it considered for further breeding; the crops it included in its portfolio; and the way information was shared (both orally and visually). A number of activities were also organized to increase the visibility of women as knowledgeable farmers. As a result, the impact of PPB on the empowerment of the involved women was indeed visible. However, the PPB team realized that this impact was undermined by gender-blind governance of seed at global and national levels. For gender-equitable outcomes of seed development to become reality, a coherent and comprehensive package of technological (e.g., improved seed) and institutional solutions (e.g., policy and governance arrangements) needs to be developed by multidisciplinary teams that span across areas such as breeding, gender, and policy.

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Decades-Long Experience on Gender Integration into the Groundnut Seed Systems of Malawi[8]

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Introduction

This case study presents learnings from a program that was implemented in Malawi since 2006, to revamp the groundnut seed system. Although gender analysis was not declared as a key focus of the project, it was the response to the gendered challenges experienced, that lead to re-engineering of key components of the program and eventually to positive impacts of the program.

Groundnuts (*Arachis hypogea* L.), also called peanuts, is a geocarpic[9] legume whose fruit (the pod) contains two to five edible nuts (seeds) that are rich in energy, protein, and numerous micronutrients. Groundnuts are widely grown in the tropics and the subtropical regions of the world, and are important to small- and large-scale commercial producers alike (Nigam, 2015). Groundnut is the most widely cultivated legume in Malawi, where it accounts for 25% of household agricultural income (Diop et al. 2003), and is the third most important crop produced there after maize and tobacco (CIAT, ICRISAT, and IITA 2013). Most of the groundnut producers are women farmers, often in female-headed households. In Malawi rural households hybrid maize and tobacco are viewed as men's crop, whereas groundnuts are identified as women's crop. Smallholder farmers account for 93% of the groundnut production volume in Malawi. Groundnut production is labor intensive, and most of the labor is provided by the family. Being a legume, groundnut is advantageous especially for low-resource agriculture, where access to inorganic fertilizers is a major challenge for resource-constrained farmers. Groundnut can fix up to 200 kg/ha of nitrogen in 106–119 days of growth (Toomsan et al. 1995). In addition, its haulms once left in the field build up soil carbon, one of the limiting factors driving low fertilizer response in most cereal-based cropping systems (Kihara et al. 2016).

Groundnut value chain: from vibrancy to collapse. Before the late 1990s, groundnut production in Malawi was regulated by a governmental parastatal organization, Agricultural Development and Marketing Corporation (ADMARC). The government, through ADMARC, provided improved groundnut seed to farmers to ensure production of quality grain for trade and processing. ADMARC also bought back

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[8] We dedicate this paper to Mr. Emmanuel Mkuwamba (1967–2017), a dedicated senior technician who worked in the Malawi groundnut breeding and in the seed systems program since 1994. He was a key member of the partnership team that implemented the activities reported in this case study.

[9] Geocarpy is a means of plant reproduction in which plants produce plants diaspores—seed and associated means of dispersion within the soil.

the groundnut grain from producers, tested for aflatoxin, and facilitated export to South Africa and the European Union. Following the World Bank-led structural adjustment programs (SAPs) in the 1990s, many governments disinvested from state corporations with the view that the private sector would invest in their operations. ADMARC's operations were affected by SAPs, including the vibrant groundnut industry (Green 2002). Access to seed of improved crop varieties shifted to those (1) with large crop area or crops that needed fresh hybrid seed each season such as maize, or (2) crops like tobacco that had had multinational interests. Private sector investment in non-hybrid seeds of crops such as legumes (groundnuts) were low because of their open pollinated nature, and most farmers would replant their seed for several generations, thus impeding the private sector's recovery of its investments. In the absence of ADMARC, the national research system of Malawi—similarly affected by SAPs—had limited capacity to produce enough early-generation (breeder and basic) groundnut seed (breeder and basic seed) for further bulking into certified seed to be planted by farmers. This minimized the availability of improved groundnut certified seed in Malawi, further driving productivity downwards.

Moreover, since most groundnut farmers were using recycled groundnut seeds, productivity was very low: at an estimated 300–400 kg/ha (FAO) compared with expected 2 t/ha (Subrahmanyam et al. 2000). The low grain yield, coupled with ineffective postharvest management of aflatoxin contamination, reduced grain quality and diminished Malawi's thriving groundnut industry. Exports to the European and South Africa markets were totally banned in the 2000s.

Revamping the Groundnut Value Chain in Malawi

In 2003 the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) and the National Smallholder Farmers Association of Malawi (NASFAM[10]), with support from the United States Agency for International Development, established a partnership to support revival of Malawi's smallholder-based groundnut value chain and industry. A key instrument for the revival was the groundnut seed system. An integrated design of implementation with four elements was used by the partnership: (1) developing a system of increasing access to seed of improved groundnut varieties; (2) increasing productivity by building farmers' skills for good agronomic practices for groundnut; (3) supporting market integration by developing appropriate grades and standards; and (4) supporting NASFAM to establish new markets for groundnut. ICRISAT deployed an agronomist, technicians, and a trade economist; NASFAM provided extension/social scientists.

Activities were initially conducted with one NASFAM member association,[11] the Mchinji Area Smallholder Farmers Association (MASFA), located in Mchinji District, Central Region. The district was selected because groundnut is a major food and cash crop there. The first early steps included (1) showcasing of

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[10] NASFAM is a national farmers organization whose vision is to be "the leading smallholder-owned business and development organization in Malawi, producing economic and social benefits for members, their communities and the country." It was originally set up to enhance smallholder tobacco production, but later diversified its crop portfolio to other crops. For more details visit www.nasfam.org

11 NASFAM'S smallest operational unit is the "club" made up of 10–15 individual members. In each club, at least 50% participation of women is encouraged. Clubs combine to form "action groups" that are key in the extension networks for dissemination of information to members and for bulking/aggregating of members produce. Action groups combine to form "NASFAMs associations."

improved groundnut varieties on-farm via results-based demonstrations and on which PVS supported by ICRISAT was done, and (2) NASFAM effected a deliberate strategy to improve the groundnut grain-marketing aspect initially focusing on the 'Chalimbana' variety. This was later followed by the introduction of new improved varieties. Within the first 2 years of operation MASFA registered 11,501 members, 33% of whom were women. Many of the participating members were not able to read and write. An adult literacy class was initiated for the members in which they were taught how to read, write, and numeracy (basic counting). In the pilot phase during the first 2 years of operation, 247 members voluntarily and successfully underwent the training (85% women) and graduated with the ability to read and write. Men were reluctant to sit in the class, preferring instead to engage in income-generating activities; however, women were comfortable sitting in the class and learning, and a higher percentage graduated than men.

Besides groundnut grain production and marketing and PVS, the partnership (ICRISAT and NASFAM) introduced improved groundnut varieties into Mchinji District. To boost the volume of improved groundnut seed in the area, community seed banks (CSBs) were used as one of the convenient vehicles to allow the membership access to improved seed without being constrained by unavailability of finances at rural household level. CSBs are village-based institutions managed by smallholder farmers for quality declared seed multiplication and dissemination within their communities. The systems' design is based on lender-borrower principle of the banking system, where loans accessed are paid back with interest. In this case a smallholder farmer who receives a certain amount of seed (usually 10 kg) as start-up is expected to return twice the quantity received (20 kg). The received seed (i.e., 20 kg) is managed centrally (seed bank) and with the farmer (borrower) retaining the excess harvest for own future production and household consumption or marketing. Seed stored at the CSB is then distributed to new farmers in the next cropping season. Under this CSB seed dissemination model, 22,000 smallholder farmers (47% women) accessed seed of improved varieties in Mchinji District.

At both grain and seed production levels, farmer groups were formed following the process of community sensitization, training on group dynamics, formation of producer clubs, followed by detailed training on club management, leadership, and constitution, but not limited to principles of groundnut production, collective marketing, and gender. Within aspects of gender, the focus was mainly on the role of women and importance of their participation in respective initiatives. With training offered on collective marketing, regional trade arrangements were brokered with buyers from Kenya, Uganda, and Tanzania. By 2016 the market share with the European Union and South Africa had been reestablished. There are publications that have documented the achievements of the accessing of the improved groundnut seed varieties in Malawi (Siambi et al. 2013).

The team that started this partnership comprised:

- An agronomist from ICRISAT–Malawi with support of several technicians
- A trade economist leading the marketing initiative
- NASFAM extension/social scientists, who led the farmer organization, group dynamics, and capacity building.

Gender Issues That Emerged while Revamping the Groundnut Value Chain of Malawi through the ICRISAT/NASFAM Partnership

Although the NASFAM component of the team had some social scientists, the focus of the partnership activities was not gender research but clearly around seed availability and good practices in processing and marketing of groundnut grain. And although neither gender research nor integration of gender into the value chain work was emphasized, gender-specific challenges kept emerging and influencing the direction of implementation of activities. Some of the critical gender issues that the partnership dealt with include:

- **Knowledge delivery to women farmers**. The program had a lot of training for farmers on groundnut production, seed production management, and groundnut processing and utilization. But looking at the trends of attendance of the invited farmers, it became obvious that whenever a meeting required that the women spend nights away from home, they would not attend. This was informed by the burden of labor that women have in providing care for the households besides crop production duties. To enhance women's participation at the meetings, the project changed the meeting planning policy. One-day meetings were planned for in villages close to homes. Moreover, if there was a critical need for the meeting to be away from the homes and for more than a day, the project would invest in childcare, and women participants were allowed to come with their young children and nannies if needed. This greatly enhanced the numbers of women participating in the project training meetings and acquiring knowledge on groundnut production and marketing.
- **Link of aflatoxin to women's groundnut-soaking practice**. Groundnuts are harvested in two stages. In mechanized systems, a machine is used to cut off the main root of the peanut plant by cutting through the soil just below the level of the peanut pods. The machine lifts the "bush" from the ground and shakes it, then inverts the bush, leaving the plant upside down on the ground to keep the peanuts out of the soil. This allows the peanuts to dry slowly to a little less than a third of their original moisture level over 3–4 days. Traditionally, peanuts are pulled and inverted by hand. In manual farming in Mchinji, mostly women shell the groundnuts, which involves long hours of sitting at home. Men prefer activities done away from home, either at the farm or at the market place.

  After the groundnut grain has dried sufficiently, it is threshed to remove the peanut pods from the rest of the bush. It is particularly important that peanuts are dried properly and stored in dry conditions. Although allowing peanuts to dry in the shell improves their quality, it becomes a main constraint in terms of labor required for shelling (done mostly by women) and takes a long time. If the shell is very hard, to be able to shell the women soak groundnut pods in water to soften the shell, then manually crack the shells by hand or mouth to access the nuts. The process of soaking pods prior to shelling increases moisture content of the pod and grain and, coupled with bulk storage, leads to an environment that is very conducive for fungal growth (*Aspergillus flavus*, the producer of aflatoxins) and subsequent mycotoxin contamination.

To improve the quality, the women were trained in postharvest management to mitigate aflatoxin contamination. They needed to understand the link between soaking, shelling, and aflatoxin contamination in order to change this practice. Communication through radio programs and all public platforms for wide dissemination was carried out. The appreciation for the negative impact of the soaking practice on groundnut quality and access to national, regional, and international markets was understood and the practice was discontinued over time. Yet this meant that the shelling task would be harder for the women, and therefore the intervention of introducing the shelling machines became a necessity. Besides Tanzanian traders with mobile threshers, there has been an emergence of local private sector actors who own groundnut shellers and charge a fee for groundnut-shelling service.

- **Preferred groundnut traits**
  - By interacting with the farmers, it became apparent to the breeding team that the *hardness of the shell* trait was a big barrier to adoption but key to safety/management of aflatoxin infestation. ICRISAT/NASFAM were promoting two varieties, one that was *rosette resistant* (one of the main diseases that impacts on groundnuts and is a high priority in the groundnut breeding program) but with a hard shell, and one that had a relatively softer shell but was not very tolerant to rosette. Within approximately 7 years (2003–2010), one variety reached approximately 90% adoption among the farmer association members in Mchinji because of the softer shell, whereas the other variety was adopted at very low rates. Shelling is a woman's task that is also labor intensive, especially when the shell is hard to crack. Women therefore chose to adopt groundnuts varieties that had a softer shell. Feedback to the breeding team in the groundnut program resulted in a refocus geared toward delivering a groundnut variety that is similar to 'CG7' in terms of shell quality but that is also resistant to rosette disease. This this is an ongoing research activity for the groundnuts breeding program.
  - Labor-saving mobile shelling machines were introduced by traders who were sourcing groundnuts for export to Tanzania and the East African region. The technology saved women's time. Traders would buy in-shell groundnuts and charge a fee for shelling. The labor needed by the women to shell groundnuts for marketing was reduced significantly. By selling groundnuts in the shell, women's labor/time was saved and drudgery minimized, and households allocated more land to groundnut farming and groundnut production was enhanced. Over time, the private sector actors in Malawi started investing in groundnut shellers and providing the shelling service at a fee to the farmers for the groundnuts being marketed.[12] This revolutionized the groundnut marketing in terms of volumes available for the market as well as quality. The average annual groundnut exports from Malawi increased from 2,000 tons/year before 2004 to more than 26,000 tons/year from 2014 to 2016 (Figure 3.4.5).

[12] For household utilization, women still shell groundnuts manually in some cases.

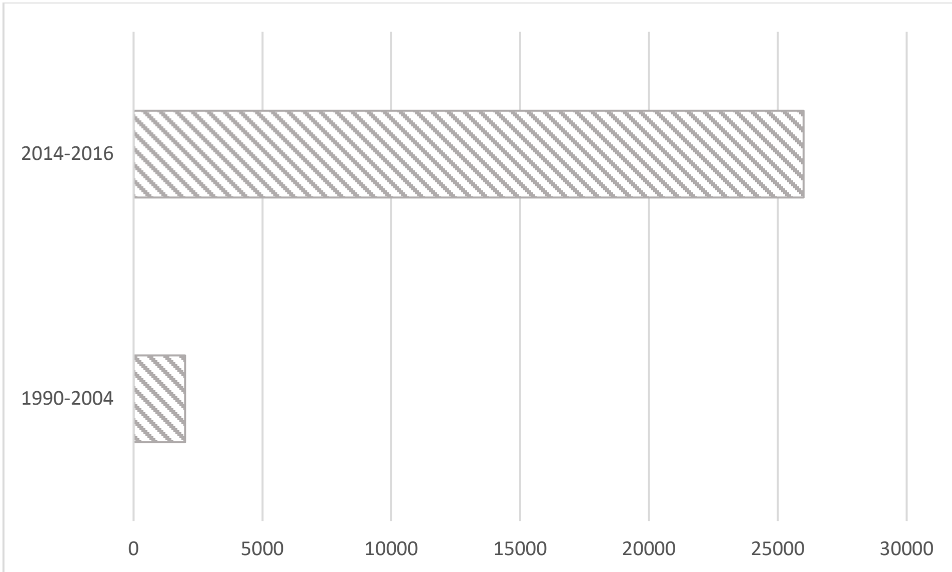

Figure 3.4.5 Annual groundnuts average exports (t) from Malawi in two periods (FAOSTAT).

— Although the groundnut variety 'CG7' was a very popular variety in Mchinji, the project members soon realized that the women farmers would grow it and sell all of its produce while they would grow their own variety ('Chalimbana') for household consumption. From discussions with the women,[13] it emerged that 'Chalimbana' had low oil content and has a tan color for the *testa*, which is preferred by the Malawian women for household use. They prefer to use the 'Chalimbana' groundnut and process it into flour—not paste/peanut butter—which they use/add to their vegetables dishes. The processing into flour is easier with 'Chalimbana', which has low oil content compared with groundnut varieties that have high oil content (like the popular 'CG7' variety) and are preferred in other countries in the region. Even though they use the 'Chalimbana' groundnut flour in their vegetable dishes, Malawian women prefer for it not to be too conspicuous in the meal (such as varieties with red skin color). Instead, they prefer the tan color varieties to the red ones. It was also noted that the high oil groundnuts, when used, cause the vegetables to go rancid faster. In ecosystems where households do not have refrigerators for cooling but would want to keep the vegetables for more than one meal, sometimes overnight, shelf-life of the dish becomes an important consideration. 'Chalimbana' groundnut is a precious gift whose seeds are passed on as gifts from mothers to daughters when they get married. This local consumption preference was fed back to the breeding team, and it currently informs the prioritization of the 'Chalimbana' variety traits in the breeding program (Tsusaka et al. 2016) for local consumption while 'CG7' is developed for the export market.

[13] In discussing this point with the project team member, I asked whether the team had collected/documented data on this process; the answer was no. Looking back, the project team realizes that this discussion and steps should have been documented, with a gender approach to it. But since it was not, the "core business" and the systematic tools of how to do it were not obvious and it was not done.

- **Malawi groundnut seed system re-established**. Groundnut seed system of Malawi was reestablished through this program. CSBs helped to disseminate groundnut seed of improved varieties within respective communities. NASFAM further established a network of commercial (individual/farmer group) groundnut seed growers with levels of commercialization to sustain supply of seed. Seed producers got the early-generation improved groundnut seeds from ICRISAT for multiplication and who made groundnut seeds available to farmers in the country. NASFAM is a member of the Malawi Seed Traders' Association and plays the role of a "seed agency," providing groundnuts seed to the Malawi Farm Input Subsidy Program. NASFAM is able to meet the needs of Malawian groundnut growers at the national level. The gap in availability of improved groundnut seed is reduced and groundnut production at the national level has increased significantly.
- **Marketing of groundnuts from Malawi**. Because of its ability to deliver on standards of quality groundnut grain, NASFAM entered into a partnership with a private investor (AfriNut) and established a company that packages confectionary nuts from Malawi. NASFAM became an aggregator of groundnut produce and a market for their farmer members. It spearheaded a process of recapturing the international market share in the European Union, South Africa, and the region by raising standards, especially in the management of aflatoxin in the critical step of shelling. Training programs, and having a lot of public communication on aflatoxin management on radio, led to behavior change among the women. The main message was to explain to the smallholder women the critical link between aflatoxin infestation, the soaking of the groundnut shells to soften, and the quality of groundnuts delivered to the markets. The critical role women farmers played in unlocking the quality constraint of the groundnut value chain was underscored. The private sector supply of mechanical shellers greatly contributed to enhancing the grain quality, too, and minimizing women's labor needs.
- **Groundnut crop, malnutrition, and hope for farmers with HIV/AIDS**. From the lessons generated from the partnership with NASFAM, ICRISAT started working with two women groups in Northern Malawi that had unique needs. They were made up of parents who were infected with HIV/AIDS or very old grandparents who were taking care of young children who were orphaned by the death of their parents' from HIV/AIDS. (Malnutrition was one of the challenges they were dealing with.) Lack of livelihood options that supported income generation reduced their options for dealing with the malnutrition challenge, among other needs like paying school fees for the young children. ICRISAT used groundnut seed production enterprise as a model for breaking the poverty cycle for the groups. One of the groups' approach was to process groundnuts into peanut and oil. But for them to be able to have a good product/reliable supply of groundnut grain, they needed to have a reliable source of improved groundnut seed. ICRISAT trained them on good practices of groundnut seed production and gave them a starter kit which allowed them to multiply groundnut seed. The farmer group distributed the seed to their members who would grow a better groundnut crop and sell to the groundnut grain group for processing; they were also trained on control of aflatoxin management. This group has now been able to generate their own income through the sale of groundnut seeds, groundnut oil, and peanut butter. They have enough income

to eat healthy, dealing with the challenge of malnutrition at the household level. Hope has been restored for the group.

- **Methods of gender analysis used in the program**. The ICRISAT/NASFAM partnership lacked a systematic process for gender data collection and analysis in the life of the project. The main emphasis of the project was on women's participation, and some data were collected on membership and participation in the partnership activities; however, cause-and-effect relationships were not analyzed. Ad hoc meetings were held to discuss the challenges encountered as well as to design ways the partnership would intervene to alleviate the challenges but to not labeling them "gender analysis" as such. In the life of the partnership implementation, these issues were not understood nor presented as gender issues or gender-responsive interventions. With the current progress in understanding on gender integration, however, it is clear to the project team that these were gendered problems for which transformative gendered solutions were designed and tested with positive results on alleviating the women's labor constraints. Traits that were key drivers of adoption decisions were acknowledged and prioritized in the Malawi groundnut breeding program.

- **Implications for the Malawi groundnut breeding program**. ICRISAT's groundnut breeding program mainly serves national groundnut improvement programs of Malawi, Mozambique, Tanzania, Uganda, Zambia, and Zimbabwe in East and Southern Africa (ESA). Kenya, South Sudan, Ethiopia, and South Africa also benefit from the program. The West and Central African countries are served via ICRISAT's Mali hub. The target environments are low altitude (200–760 masl) with mean ambient temperatures of 30°–33°C; medium altitude (760–1,300 masl) with ambient temperatures of 27°–30°C, and dryer ecologies.

  The goal of the breeding program is to develop and deploy resilient and highly productive groundnut varieties that meet diverse needs and demands of the groundnut value chain of ESA and other markets. The program has prioritized traits that reflect value chain/actor demands and needs, based on the experiences of the last decade through the ICRISAT/NASFAM partnership to include two groups of traits:

  — **Input traits**: These include biotic stresses such as groundnut rosette disease, rust, leaf spots, and aflatoxin contamination. Other minor biotic stresses include the leaf miner, witch-weed, and pests. The major abiotic stress is drought in low-altitude and semi-arid environments. End-of-season drought affects groundnut production in medium altitude ecologies. Nutrient use efficiency is a new focus, especially for resource-constrained smallholder farming, the main production system for groundnut.

  — **Output traits**: Currently, these include market and end-use traits such as confectionary quality, high oil, and micronutrient content (iron and zinc dense), shelling out turn, and ease of shelling. Every season the breeding program generates new crosses carrying these traits.

  Capture of gender-disaggregated data has now been built into all our research for development activities. Women and young people are particularly engaged during variety development as well as knowledge and technology dissemination. Building capacities for gender analysis among staff, refining data collection strategies, and applying a systematic approach to gender analysis/ gender integration are prioritized an important level in mediating adoption of new groundnut varieties and technologies for aflatoxin management as well as promotion of nutrition-sensitive initiatives in Malawi and the region.

Conclusions

The shelling of groundnuts is a difficult and laborious task done by women. By not understanding the gender dimension of this task that facilitated aflatoxin infestation, and hence the quality of groundnut grain, may have contributed greatly to Malawi's loss of its share of the European Union market.[14] This despite all the other steps in the breeding cycle being done well. When the gendered constraints became clear to the project team, and responsive and empowering strategic interventions were designed, the groundnut value chain was turned around. The project team, however, did not have principles and guidelines on how to systematically design the gender research questions. Nor did it have the skills to design gender data collection in a systematic way that would lead to rigorous gender analysis and so inform project monitoring, evaluation, and learning at critical stages. Even now, as we attempt to communicate the lessons learned in this project, it is challenging to show the linkages between the activities implemented, the gender-empowering strategies, and the outcomes that were obtained without the data to refer to. Yet the experiences and impacts of this program demonstrate that it was strongly gender responsive. The implementation team is able to, in retrospect, pinpoint the interventions that tackled hurdles for women farmers, with benefits accruing to the whole groundnut value chain, beyond the borders of Malawi. It also demonstrates a reengineering of the groundnut breeding program that prioritizes traits that respond to women needs; namely the need for soft shell as well as low oil content in groundnut varieties. This case goes a long way to underscore the importance of having design principles that guide gender integration into research along the breeding cycle.

Lessons Learned from the Groundnut Seed/Grain Program in Malawi

The groundnut seed project was highly gender responsive, although reflecting back the implementing team's perspective is "we did not do any gender research" in the project. This demonstrates the big gap in articulating the gender research question in an integrated manner in programs versus seeing gender research as a separate issue. In this program the implementation team would deliberate on actions to take in response to the *gendered* challenges they faced. The program actions were responsive to gender needs with many positive results of the intervention, but "did not identify the problems as gender issues and even though some gender disaggregated data were collected, the data were not subjected to analysis and reporting,[15] away from the core indicators tracked by the partnership (i.e., availing seeds, improving on-farm production and marketing of the groundnut seeds/grain). When focus group discussions were

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[14] Dr. Moses Siambi, personal communication, 25 October 2017.

[15] In discussing this point with one of the NASFAM officers, two challenges were identified on why this was not done: the project had no gender scientist and the project reporting structures did not ask for a gendered analysis.

carried out, the qualitative data were not analyzed in a systematic way that could be referenced later, being that “it was not part of the program focus.” Some of the gender issues documented pertaining to this program were raised ex-post, during economic studies on adoption and impact survey work years after the program implementations had ended. It is not clear whether the constraint was strict formulation of the project objectives and deliverables, which did not allow for adaptive actions to improve the quality of gender analysis in the team, or whether the challenge was in getting a person skilled/experienced enough to spearhead the gender integration component, learning, and analysis.

This program demonstrates the potential benefits there are in integrating gender research and analysis as a core part of program activities and in having design principles that would guide a project team in identifying, analyzing, and tracking the gendered issues in it. Having a team that includes the breeders, the seed systems actors, trade economists, extension officers, and gender scientists working on one “compelling agenda” greatly improves the value of work delivered. In this program, the gender issues came out very strongly in the process of program implementation. But because they were not considered as core areas of focus, the relevant tools that would support data collection were not developed and the data on gender impacts and processes were not collected. Nor were the lessons anchored on data analysis (although they were adopted in an ad hoc manner in time). Opportunities for documenting the gendered impacts were also missed. Gender dynamics are the heart of all farming activities, and not identifying them can lead to an intervention’s failure to attain its desired impact.

Acknowledgments

We acknowledge the ICRISAT/NASFAM implementation team that has had to reflect on program activities they implemented more than 10 years ago, in order to tease out the gender issues that they faced, acted on, and allowed us to learn from. We benefited from a review and comments by Dr. Chris Ojiewo, the seed systems theme leader at ICRISAT. The anonymous reviewers who gave very valuable contributions on the earlier drafts are highly appreciated.

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4. LESSONS LEARNED

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Introduction

This chapter synthesizes lessons from the preceding case studies for future action aiming to integrate gender and gender analysis into breeding. Chapter 2 explained why breeding programs with development goals and concerned about the impact on poverty reduction and gender equality can benefit from using gender analysis. Chapter 3 presented 10 case studies illustrating how and when gender was considered in a variety of commodities and breeding programs. This final chapter will discuss when and how breeding programs can draw on these case studies to improve the gender responsiveness of critical[1] decisions made at different stages in the breeding cycle itself[2] and the entire breeding process.

Gender can affect producers' adoption of new varieties or animal breeds in two interdependent ways. First, differences in the roles and resources, power, and status of men and women affect their preferences for, access to, and choice of technology. Second, those same gender differences can affect the distribution of benefits among men and women who are potential users of new varieties or animal breeds. Chapter 4 examines how breeding programs featured in the case studies made use of gender analysis to inform critical decisions—or missed opportunities to do so. Without delving into explanations of gender analysis, the chapter will consider the strengths and limitations of the different kinds of gender analysis carried out in the case studies. The final product of this chapter is lessons from the case studies for how to use gender analysis effectively in breeding.

The case studies were not selected to be representative of breeding programs in general but for their unique interest as examples of ongoing experience of considering gender at different stages of the breeding cycle. Consequently, we cannot generalize about practice from the case studies. We can, however, draw some suggestions for promising approaches and lessons learned. Each case study is a reflection on the following questions provided as a guide to the authors:

1. What was the driver for carrying out research on gender (e.g., low adoption, literature showing important role of women in production, etc.)?
2. What have you learned generally in the process of this research? What would you do differently if you went back?
3. What would you recommend to researchers thinking to apply the same methods/approaches?

[1] "Critical" refers to a decision that can lead to different adoption and impact outcomes, depending on whether the decision considers relevant gender differences in the population of intended users.

[2] Chapter 1 includes a diagram of the stages.

4. What have you changed in your breeding program because of your research on gender?
5. How has the breeding process itself resulted in community-level impacts, especially gender relations?

Critical Decisions in the Breeding Cycle

This section provides a brief overview of the framework to be used for analyzing how the case studies make use of gender analysis in critical decisions in the breeding cycle. The framework is the product of deliberation by participants in two workshops facilitated by the CGIAR Gender and Breeding Initiative.[3] The working groups used these case studies as an input for their discussions, which resulted in a decision checklist.[4] The checklist contains seven "critical decisions" based on the flowchart shown in Figure 4.1 that depicts the decisions (amber boxes) occurring at key stages in breeding (orange diamonds). The double-headed arrows signify that taking gender into account in the breeding process is cyclical and involves learning. For example, a breeding program with development goals may begin to consider gender in decisions 5, 6, or 7 and, as a result, learn the importance of taking gender into account in future, in earlier decisions in the breeding cycle, such as decisions 3, 2, and 1. Several of the case studies illustrate this learning process. The stages of breeding in Figures 1.1 and 1.2 in Chapter 1 are for plant breeding; a full explanation of the critical decisions can be obtained in GBI Brief No. 1[5].

The decisions (amber boxes) depicted in Figure 4.1. were identified as crucial points in a breeding cycle when putting the principles of gender responsiveness into practice could determine whether the adoption and impact of its technology (varieties and breeds) have positive, neutrall, or negative implications for women users. The expected benefits for breeding programs of integrating gender into the seven crucial decisions include (1) better understanding of the role gender plays in demand for the products of breeding by breeding teams; (2) goals and expected outcomes defined for breeding programs that take gender into account; and (3) well-identified breeding products designed and evaluated based on knowledge of how gender is relevant to who will use them and why. The next section discusses how the case studies illustrate some of these expected benefits from the use of gender analysis.

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[3] http://www.rtb.cgiar.org/gender-breeding-initiative/

[4] The first workshop, held in October 2016, brought together breeders and gender researchers who identified important gaps in evidence and the "must-haves" for gender-responsive breeding (see CGIAR Gender Research Action Plan, Brief 4, Figure 3). The second workshop, held in October 2017, built on these results by commissioning three Working Papers: Working Paper No. 1 "Gender and social targeting in plant breeding"; Working Paper No. 2 "From market to demand breeding decisions"; and Working Paper No. 3 "State of the knowledge for gender in breeding: case studies for practitioners." Small groups drew on these to develop practical advice for addressing critical decision points and tailoring the decisions checklist.

[5] https://cgspace.cgiar.org/bitstream/handle/10568/91290/GBI%20BRIEF%201.pdf?sequence=1&isAllowed=y

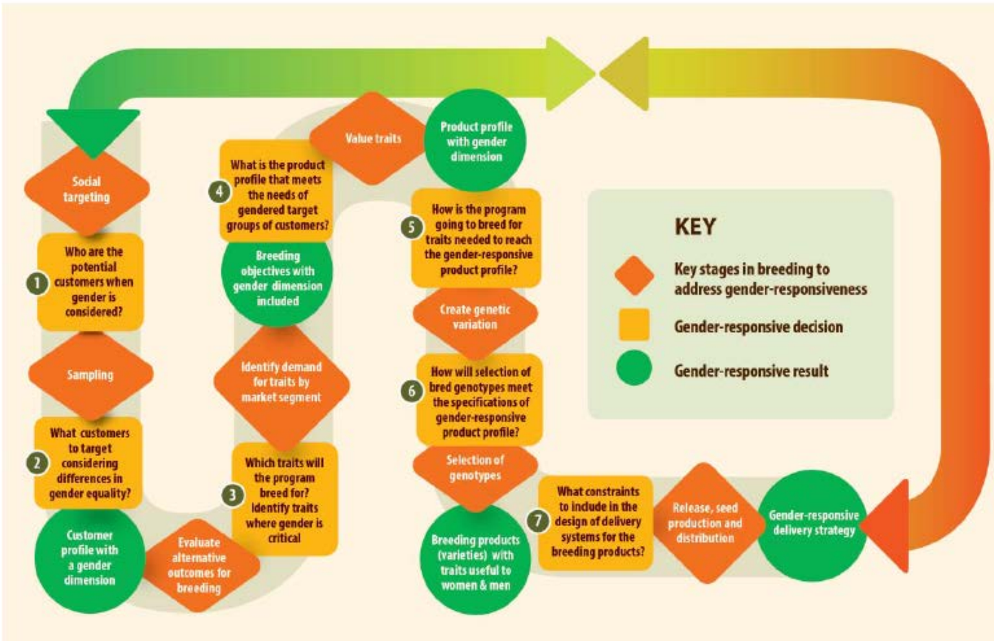

Figure 4.1 Descision checklist.

Box 4.1 summarizes the seven critical decisions specified in the decision checklist, a tool for checking whether decisions at key turning points in the breeding cycle include relevant gender considerations. Each decision in the checklist requires specific information about gender differences. The cases will be examined to understand which of the decisions described in Box 4.1 is addressed in the case, what information from gender analysis informed that decision, and how the program benefitted.

Box 4.1 Seven Critical Decisions for Gender Responsive Breeding with Development Goals

1. Who are the potential customers for breeding when gender is considered?

Makes a first cut at assessing the relevance of gender differences for defining "market segments" or groups of customers for actual or future breeding products.

2. What customers to target? What is the justification for targeting one segment of the user population versus another, considering differences in demand among men and women?

Prioritizes and selects the customer groups or market segments to be targeted and characterizes their demand (customer profile). Refines the analysis produced in decision (1) to assess whether gender differences among customer groups are representative of the target population for the breeding program.

3. Which trait preferences could the program potentially breed for? Which existing or new-bred plant or animal traits could potentially satisfy some aspects of identified demand?

Focuses the analysis of demand in decision (2) on understanding gendered trait preferences of customer groups or market segments to understand what breeding can potentially do and for whom?[6]

[6] For example, if the women's demand is for "soft skin" on an apple, what is "soft"? Are there existing apples with skin women consider as "soft?" Do the women mean "less chewy" skin, or "easier to peel" skin? Do some of the apples the women grow have acceptably soft skin if the tree gets enough water at a certain stage of fruit formation? At this point the decision incorporates gender by analyzing an expressed preference to identify one or more traits that could potentially be bred for (or indeed, might turn out to be beyond the scope of breeding).

4. **What is the product profile or package of traits that best meets the needs of a given target group of customers? What product can feasibly be developed to meet the priority demand of the most important customer group?**

Identifies one or more priority products (or packages of traits) that meet breeders' specifications for feasibility and supply an important customer group**,** taking different trait preferences of men and women into account. Narrows down the options from decision (3) to a "breedable" product.

5.How is the program going to breed for the traits needed to reach the product profile that best meets the needs, taking gender into account? Is new variation needed to meet the specifications of the product profile and how will genotypes be selected?

Uses the profile of a desired product from decision (4) to determine the specific, technical breeding objectives and methodologies needed for that product to meet the identified gender-responsive demand and breeding feasibility constraints, with a focus on evaluating whether and how new sources of variation need to be introduced.

6. How will selection of genotypes meet the specifications of the gender-responsive product profile?

Uses the profile of a desired product from decision (4) to determine the specific, technical breeding objectives and methodologies needed for that product to meet the identified gender-responsive demand and breeding feasibility constraints, with a focus on testing that includes gender-relevant criteria to select and advance genotypes to final release of crop varieties or animal breeds.

7. What constraints to address in the design of delivery systems for the breeding products?

Manages the product launch and dissemination and its interface with delivery systems so that crucial gender-related constraints and opportunities are addressed.

Based on GBI (2018) Critical Decisions for Ensuring Plant or Animal Breeding is Gender-Responsive Brief No.1.

Consideration of Gender in Critical Decisions for Gender-Responsiveness

Cases were selected, to the extent possible, to provide examples of how gender was considered at different stages in the breeding cycle. Table 4.1 maps the case studies against the seven critical decisions presented in Box 4.1 to specify decisions in which (1) the breeding program considered gender a priori (denoted by x), and (2) because of gender analysis, the program learned to consider gender and/or the authors report intention to consider gender in future (denoted by ✋).

Although no single case encompasses all seven critical decisions, together the case studies illustrate the inclusion of gender in analysis in order to understand demand and profile customers. Some cases explore potentially significant trait preferences among different customer groups. There are also examples of considering gender to identify representative profiles of gender-differentiated adopters of actual or future breeding products. Other examples involve efforts to define the product profile or a package of traits that takes account of user-relevant gender dimensions or to value traits accounting for differential impact on men and women. Finally, there are examples of approaches taken to introduce new variation in breeding considering gender-differentiated preferences; or to conduct selection, testing, and seed distribution considering gender-related constraints and opportunities.

All the breeding programs featured in the case studies work on a specific commodity with a preexisting supply of breeding products at the time of introducing gender analysis. Their initial motivation for considering gender is the question of how to accommodate their existing or planned breeding product so that it benefits women as well as men. Although there is probably not much re-engineering that can be done to an existing breeding product to benefit both men and women, it is risky to conclude this without doing the relevant gender analysis. For example, if women express a preference for varieties that are tolerant to low soil-fertility conditions and advanced materials are always grown out and selected on experimental plots with relatively higher fertility conditions, then there is an opportunity for breeders to take gender into account in their decisions about the conditions under which to screen and select (decision point 6). In this example, breeders may opt to screen and select a set of existing materials under soil-fertility conditions that more closely represent the actual growing conditions faced by women producers.

All of the case studies, irrespective of the critical decision point involved, have prompted learning and action (or the intention) to consider gender at an earlier stage. Table 4.1 highlights this learning for each case. For example, during seed multiplication (decision point 7), *Groundnut Malawi* encountered practical difficulties in the effort to improve seed quality. When training farmers, who were mainly women, it was hard to convince them to abandon their labor-saving postharvest practices that exacerbated aflatoxin contamination of the grain. It became apparent to the breeding team that the women's preference for a soft-shelled, easily processed variety, albeit more susceptible to aflatoxin contamination, was a serious barrier to adoption of a hard-shelled, aflatoxin-resistant variety that was hard to process. Considering gender in the choice of traits to include in the product profile led the groundnut program to shift gender considerations upstream (see Table 4.1, from decision point 7 to decision point 4). The breeding program redefined the desired product as a groundnut variety with the shell quality preferred by women but that is also resistant to disease. This redefined, gender-responsive product is an ongoing research activity for the groundnut breeding program.

In *Barley Syria*, gender analysis was initiated during PPB seed multiplication (decision point 7). A gender perspective on women's participation in the program and trait preferences was included during PPB selection (decision points 5 and 6). Then, *Barley Syria* learned that women did not participate for the following reasons: they were unaware of the program; they did not have decision-making opportunities over the family land; they had assumed that the program was for men; and they were not even interested in barley! This program went back to the drawing board to include consideration of gender differences in understanding its role in demand (decision point 3). This reconsideration led the program to respond to a much expanded understanding of demand from women, and to add trials with wheat, chickpea, lentil, and cumin because the women had expressed interest in them. In *Maize China*, the shift of attention to gender to an earlier stage in the breeding cycle took a different form. Breeders started by considering gender in testing existing varieties (decision point 6) and then, after realizing that local landraces conserved on-farm by local women could be a potential source of valuable new breeding material, brought gendered knowledge and selection criteria upstream into the development of new varieties (decision point 5). *Sorghum quality Mali* also undertook a fundamental shift in product definition in response to research on gender undertaken during testing of experimental varieties (decision point 6). The program found that although sorghum is locally considered a "man's crop," women also grew it for their own specific uses. The program therefore introduced gender criteria into the testing of new, experimental varieties. Women's involvement in evaluations threw light on the importance of low soil fertility and grain decortication losses. New genetic variability was introduced when gender analysis showed that the genetic pool did not contain a trait important for women, notably adaptation to P-deficient soils, a new criterion. As a result, the program shifted consideration of gender upstream to be incorporated into fundamental, long-term changes in the program's definition of the traits that its new varieties should incorporate.

Matooke Uganda provides another clear example of this learning effect, where study of trait preferences during testing (decision point 6) was motivated by the desire to increase adoption of an existing product. This led to rethinking of the product profile (decision point 4) and realization that gender has a role in demand that needs to be considered earlier in the breeding cycle (decision points 1–3). In response to the preferences identified when gender was first considered, sensory and consumer acceptability evaluation studies were introduced during on-farm testing and evaluation. The identification of some women's trait preferences that were both different from men's trait preferences and determinants of acceptability of the new hybrids caused breeding efforts to refocus during characterization and prioritization of new *matooke* varieties. Subsequently, the program decided to make a systematic effort to understand demand with a gender perspective (decision point 3) via research on trait preference for men and women, and how this explains low levels of adoption of released varieties. This research illuminated the gender differences associated with demand for marketable qualities (mainly but not exclusively prioritized by men) and for cooking and consumption-related qualities (mainly but not exclusively prioritized by women). This case study highlights the need to analyze the complexities of demand expressed by different socioeconomic groups, some of which are likely to be predominantly women, possibly with their own specific preferences, and some of which include men and women with common preferences.

The case studies illustrate learning loops, many of which were serendipitous rather than intentionally managed, in which consideration of gender in one of the later stages in the breeding cycle generated recognition of need for incorporating gender into critical decisions in preceding stages. *Cassava Nigeria* illustrates how an adoption study designed to understand what was happening to of released varieties (decision point 7) was harnessed to provide feedback on varietal preferences to guide future work and became the vehicle for detailed study of gender-differentiated preferences (decision point 2). This learning loop is needed when breeding products are initially formulated around the question of how to improve the supply of a given commodity, as distinct from how to meet needs of a given beneficiary group. *Beans East Africa* provides an example of how the learning loop can be enriched by the study of demand. This breeding program already had information that a fast-cooking bean would be popular with growers because they discovered a bean with this trait was being independently multiplied and widely disseminated by farmers in the region. The case study shows how taking gender into account in subsequent investigation of the demand for fast-cooking beans generated learning in the breeding program about the value of building a social profile of different customer groups (decision point 1) as well as making changes in selection methodology (decision point 5). In *Sorghum Quality Mali*, the involvement of women in participatory varietal evaluations (decision point 5) led to the discovery of hitherto overlooked quality traits, and generated learning that taking gender into account in earlier stages of the breeding cycle (decision point 4) prevented the program from inadvertently eliminating some traits desired by users. The lesson here is the value of conscientiously managing the learning loop to ensure that feedback from gender research informs decisions at different stages in the breeding cycle.

An important feature of what was learned from gender analysis in these case studies is that when the preferences of men and women are compared, the resulting picture is not always one of clearly divergent preferences. As Chapter 2 discussed, cases found instances where men and women agreed about some traits and differed about others, or about the value of a trait or a combination of traits. For example, in Syria, both women and men valued large seed, healthy plants, drought resistance, and color. However, some other traits were more important for women than for men, namely spike hardness and plant height. This is one reason why a simple comparison of the “likes” and “dislikes” of men and women with respect to traits seldom provides a reliable foundation for developing a gender-responsive breeding product. Unquestionably, strong divergence in trait preferences between men and women is a signal that requires attention. But even when there is no clear picture of different preferences, effective product development requires analysis of the reasons for gender inequality that will drive men and women to make different adoption choices. In Nigeria for example, it was found that women and men are looking for a “basket” of cassava types and traits including in ground storability, ease of peeling, and weed competitiveness. The cassava study concludes that options are needed to satisfy multiple types of preferences. This was also found in Mali, where households made clear trade-offs among traits, seeking diverse varieties to help manage risk and meet a wide range of production, consumption, and marketing requirements. This has significant implications for breeding programs since it precludes settling for a one-size-fits-all variety. One lesson here is that if differences between men’s and women’s trait preferences are not immediately obvious—even if none are detected—it is important to have looked for them.

Beans East Africa explains this dilemma succinctly, with a study that showed why differences between men’s and women’s preferences are seldom clear enough to support the labeling of any trait as a “man’s” or a “woman’s” trait. The program already had substantial knowledge about gender-differentiated preferences from PVS carried out during testing. However, selection for men’s versus women’s preferences did not lead to straightforward adoption by men or women producers. Numerous varieties were released but few farmers took them up. The program did not understand the trade-offs farmers were making among different traits or how factors other than gender, such as wealth and age, played a role in trait preferences and adoption decisions.

To remedy this deficit, the bean breeding program undertook a study that discriminated bean variety users into different customer groups or market segments with different preferences. Segmentation showed how preferences were influenced by the intersection of gender with other social factors. With a description of the gender composition of different market segments or customer groups, and an explanation of each segment’s demand for individual traits or packages of traits, breeders can anticipate and consider how men’s and women’s needs are being addressed when a given breeding product is defined. This reduces the need for retrofitting gender-differentiated preferences as occurs in the case studies. The bean program concluded that time and money can be saved if the users are defined early in the breeding cycle (i.e., decision points 1–3) and their interests and welfare built into setting breeding priorities. This is an important lesson from these case studies.

Gender Analysis in the Case Studies

This section looks at what can be learned from the strengths and limitations of the different kinds of gender analysis carried out and aspects of the approaches used that deserve replication. This involves a wide range of approaches and methodologies, albeit with some striking commonalities.

Table 4.1 notes where a case study used PVS or PPB, and shows that all the case studies except *Cassava, Nigeria* involved use of PVS. Participatory evaluation can be used to generate information on trait preferences if participating farmers are asked for explanations of their rankings of materials. Thus, PVS motivated to understand the drivers of men's and women's trait preferences provided a relatively straightforward starting point for gender analysis for many of the case studies. What is striking is that before considering gender, PVS in these case studies did not involve selection of its participants based on a socio-demographic profile of the customer or market segment whose opinion was being sought.[7] This explains why gender was absent from PVS. Economists in *Beans East Africa* made a specific innovation to collect socioeconomic data that enabled the program to characterize whose varietal selections were being captured in PVS. They concluded gender-differentiated preferences can be hard to detect with PVS tools. The lesson here is that gender-responsive PVS needs to integrate collection of data on all the social differences besides sex that affect adoption, such as age, wealth, and education.

As several of the case studies observe, involving women in on-farm trials did not provide the insight into trait preferences needed to guide breeding. *Groundnut Malawi* comments on the shortcomings of exclusive reliance on women's participation in such trials, where "the emphasis of the project was on 'women's participation'," defined as their presence in some activities like field days and training exercises. Some data were collected on membership and participation in the partnership activities, but "cause-and-effect" relationships were not analyzed. *Sorghum Quality Mali* observes that understanding gender roles, responsibilities, and ambitions requires explicit investment in gender analysis independent of simply having women participating in the breeding activities.

The deficit of attention to gender analysis is symptomatic of a wider problem, the lack of socio-demographic information about a breeding program's customers or key market segments and the demand they represent to inform decisions about breeding products (GBI Working Paper No. 1[8]). This information is necessary for performing the social demographic analysis involved in decision points 1–3 shown in Table 4.1 at a scale that allows generalizations to be made about groups of users and the men and women within them, irrespective of whether qualitative, quantitative, or mixed data collection methods were used. And although these case studies examined gender analysis, sparse attention was given to documenting the extent to which their comparisons of men's and women's trait preferences can be generalized to a significant-sized group of customers for the breeding program's products. Generation

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[7] Selection done in this way was included in the original methodology for participatory evaluation of technology and this information would be generated during Social Targeting and Sampling, as described in Figure 1. However, in practice PVS has been widely delinked from understanding the socioeconomic characterization of the farmers doing the selections.

[8] https://cgspace.cgiar.org/bitstream/handle/10568/91276/Working%20Paper%201_STP_FINAL%20VERSION_18_02_08.pdf?sequence=1&isAllowed=y

of representative data for customer profiling was featured in the *Cassava Nigeria* and *Beans East Africa*: both demonstrate the importance of this type of information for identifying and understanding demand so that breeding products are effectively targeted to their intended users.

The case studies illustrate the utility of combining qualitative and quantitative social science research methods. Beans, for example, used a CE methodology. Survey research was used mainly to follow up on adoption and showed how adoption studies can be utilized to provide feedback on gender-differentiated trait preferences. Other case studies demonstrate the importance of qualitative gender analysis for drilling down beyond simple comparisons of men and women to explain how gendered preferences are shaped by inequalities in resources, markets, institutions, and policies. For example, qualitative research teased out the gender differences in power, a key constraint to the sustainability of the *ololili* system, that needed to be considered before the system could be improved. *Matooke Uganda* first conducted a small number of in-depth interviews and then complemented this with survey research.

Lessons about using gender analysis from the case studies highlight the

- Importance of incorporating socioeconomic data collection into PVS and PPB
- Advisability of avoiding reliance on "women's participation" in activities instead of using disciplined gender analysis
- Utility of mixed methods
- Necessity of ensuring that data support generalizable conclusions about gender differences in a meaningful customer group
- Requirement to explain how multiple facets of social difference, including but not limited to gender, translate into trait preferences and subtle trade-offs among traits

The cases studies illustrate that gender analysis in breeding is still in a formative stage, evolving from ad hoc discovery of gender-differentiated traits. In several case studies, gender analysis undergoes its own learning process to identify a workable approach and combination of methods, while seeking legitimization within the larger program. In some instances, this limited the scope and ambition of the gender analysis undertaken to sub-projects, whereas in others it has taken a national or regional scale. Several authors explicitly state the major lesson to be learned: the importance of social and gender analysis as a core activity, grounded in a well-resourced capacity for socioeconomic research and integrated into the breeding research team. *Groundnut Malawi,* for example, notes that capture of sex-disaggregated data has now been built into all ICRISAT's research for development activities: "Having a team that includes the breeders, the seed systems actors, trade economists, extension officers, and gender scientists working on one 'compelling agenda' greatly improves the value of work delivered." (see). As the *Barley Syria* program found, adoption of a research approach is not the whole story. Taking gender into account needs a committed team involving breeders and social scientists working together.

Lessons from Approaches to Integrating Gender into Breeding Research

This section looks selectively at aspects of the diverse approaches described in the case studies to highlight models that may be of further interest or deserve replication. In general, these can be described as the procedures, operational rules, and policies that programs institutionalized to ensure that gender was well-integrated into work-in-progress. Some of these procedures include adapting criteria to select farmers to host and evaluate trials; changing the protocols and criteria used to evaluate test materials; the way information was shared; and the way seed was distributed.

Several cases proactively engaged both women and men in the breeding research. It was noted in the previous section that women's participation in activities as distinct from participation in research is not a substitute for socioeconomic and gender analysis. Such research has the objective of explaining social difference that underpins gender inequality and assessing differences in demand for breeding products, at scale. In contrast, the benefit of involving men and women users in PPB and PVS is that it provides rapid insights into users' preferences and choices, enhances user understanding of new products, paves the way for informed farmer experimentation, and empowers early adoption. In addition, the case studies found that proactively engaging women in on-farm research enhances their status.

Participatory Sorghum Breeding Mali adopted several internal policies or procedures to reinforce women's participation in PVS. For example, they established the rule that participatory variety testing will be conducted in a village only if at least four women conduct their own trials. As well, initial discussions with women and men farmers were done separately when identifying evaluation criteria or planning activities. The outcomes of discussions are presented to everyone collectively and when necessary facilitation is provided to arrive at a position acceptable to all. This strengthened women's position and provided them with some independence in the conduct of on-farm trials. Women were empowered to engage in various seed related activities, which increased their access to new varieties and contributed to increasing diversity of improved varieties in their villages. Their participation increased, and their voices heard more strongly due to facilitated discussions with both men and women about their observations of trials. With these formally instituted practices, *Participatory Sorghum Breeding Mali* established a routine for accessing farmer opinion and active contribution to varietal evaluation by men and women alike. Moreover, the authors note that the interaction with farmers led to insights that were subsequently deepened with research on gender.

In *Barley Syria* the program proactively intervened when the participation of women was undermined. To support women's control over seed, the PPB team ensured that the preferences of both women and men would be considered in deciding which crosses to make; and women and men would get access to the seed they had participated in selecting. The *Groundnut Malawi* case provides a strong example of a program taking extra steps to make the inclusion of women possible. Policies regarding meetings were changed so that generally meetings would be only for one day. If there was a need for a multi-day meeting, the project would provide childcare. This can make a critical difference with the inclusion of women who have primary responsibility for the care of infants and young children. For the *Chicken Ethiopia* case, women's domestic responsibilities would inevitably pull them away from interviews and data collection efforts. Women often had to cut short discussions, so conducting interviews in homes at convenient times allowed women to carry on their required tasks. This was addressed by avoiding times of year that are particularly busy with land preparation of other on-farm activities or religious activities. *Beans East Africa* showed the importance of using complementary settings to elicit preference data because men did not express their preference for short cooking time in all settings.

Several cases illustrate how working with a development project or external change agent helps to anchor gender analysis in breeding in addressing demand. This may involve community development professionals in active facilitation of women's participation in farm trials, PVS, and seed-related activities. In *Groundnut Malawi*, attention to gender in breeding was initially serendipitous and emerged from the challenges encountered on the ground by the development project concerned with training farmers in seed multiplication. In *Barley Syria*, partners were engaged to expand women's access to critical machinery, information, training, and exchange visits with other farmers and scientists. Long-term engagement and collaborations with local partners in *Participatory Sorghum Breeding Mali* were found to foster trust and rapport between farmers and members of the development and research community. These interventions, over time, contributed to women becoming more visible as farmers in their own eyes as well as that of their communities.

Conclusions

Lessons refer to insights or good ideas that may help to improve future performance of breeding when taking gender into account. Lessons are not understood as generalizations that necessarily refer to commonalities among all the cases. A valuable lesson may derive from reflection on the experience of taking gender into account in one highly instructive case. For example, *East Africa Beans* is the only case study in which the collection of socioeconomic data with a gender dimension was incorporated into PVS to improve understanding of different trait preferences of men and women. This is a useful practice that adds value to PVS and makes it possible to interpret not only gender differences in the opinions obtained with PVS, but also the intersection of gender with other, influential socioeconomic characteristics of users. A lesson may also be derived from experience that is seen to repeat itself in several instances. This is certainly the case with the conscientious management of a learning loop that feeds information about gender differences into decisions taken at early stages in breeding as well as decisions made when release of new varieties or animal breeds is imminent. Albeit in very different ways, all the case studies manifest some experience over time with the benefits of feeding information on gender into an earlier stage of breeding than where they started out. Lessons from the case studies summarized in Box 4.2 are all derived from the preceding sections of this chapter, where they are discussed in detail and illustrated.

Box 4.2 Summary of Lessons from the Case Studies

- When the preferences of men and women are compared, the resulting picture is not one of clearly divergent preferences. It is unrealistic to expect a picture of consistently diverging preferences between men and women because some women may have interests in common with men while others do not. Comparisons of trait preferences based on sex alone may be misleading.
- Women's participation in activities is not a substitute for disciplined socioeconomic and gender analysis. Understanding gender roles, responsibilities, and ambitions requires explicit investment in gender analysis independent of simply having women participating in the breeding activities.
- It is desirable to conscientiously manage a **learning loop** within the breeding cycle to ensure that gender research informs decisions at different stages in the breeding cycle.
- Breeding teams can only fully consider how men's and women's needs are being addressed if they have a description of the gender composition of different customer groups or segments; and an explanation of each segment's demand for individual traits or packages of traits.
- Time and money can be saved if the users are defined early in the breeding cycle through a study of demand in different market segments or user groups.
- Gender-responsive PVS needs to include data collection on the participants' social background, in addition to sex, such as age, wealth, and education. This step should be used to correlate their varietal choice and preferred traits with important social differences that affect adoption.
- Breeding programs can change their own procedures, operational rules, and policies to ensure that gender is well-integrated into their work-in-progress. These procedures include adapting criteria to select women and men as farmers to host and evaluate trials; changing the protocols and criteria used to prioritize which traits merit breeders' attention; introducing gender-responsive criteria to evaluate test materials; and considering gender in the way information is shared and the ways seed is multiplied and distributed.

Table 4.1 Consideration of gender in critical decisions for gender responsiveness in the case studies

Stage of Case Study's Focus in the Breeding Cycle	**Setting Breeding Priorities**				**Selection**		**Testing Experimental Varieties**		**Seed Production and Distribution**	
Critical Decision **Legend:** **x set out to consider gender in this decision** **✋ learned to consider GA in this decision**	*Bean Market East Africa*	*Cassava Adoption Nigeria*	*Ololili Forage System Tanzania*	*Chicken Ethiopia*	*Maize PPB China*	*Sorghum Quality Mali*	*Banana Uganda*	*Sorghum Testing Mali*	*Barley PPB Syria*	*Groundnut Seed Malawi*
1.Who are the potential customers for breeding when gender is considered?	✋									
2. What customers to target? **Documents generalizability, uses representative data (sampling)	X x	✋ X	x							
3. Which gendered trait preferences could the program potentially breed or select for?	x	X	✋	✋			✋		✋	
4. What is the product profile or package of traits that best meets the needs of a given target group of customers, taking gender into account? What product can feasibly be developed to meet the priority demand of the most important customer group?	x	X	x	x	✋	✋	✋		**x** **PPB**	✋

Stage of Case Study's Focus in the Breeding Cycle	**Setting Breeding Priorities**				**Selection**		**Testing Experimental Varieties**		**Seed Production and Distribution**	
5.How is the program going to breed for the traits needed to reach the gender-responsive product profile? Is new variation needed to meet the specifications of the product profile, and how will genotypes be selected?	✋		x		x PVS	✋	✋	✋	**x** **PPB**	✋
6. How will selection of bred genotypes meet the specifications of the gender-responsive product profile?	x PVS		x PVS		x	x PVS	X PVS	x PVS	x PVS	✋
7. What gender-relevant constraints to consider in the design of delivery systems for the breeding products?		x[1]	x		x			✋[2]	✋	**X**

[1] *Cassava Nigeria* initiated study of gender differences in trait preferences with an adoption study of past releases.

[2] *Participatory Sorghum Breeding Mali* conducted a panel follow-up study of adoption at two points in time. Inclusion of women's criteria in selection led to inclusion of women's preferred varieties in seed production.

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Jonas KIZIMA is a pasture agronomist researcher specializing in tropical pastures and forages and rangelands improvement. He has been training on technologies on forage production and technology transfer strategies. Experienced in management of natural resources, he has been providing extensive advisory consultancies to private farmers who want to establish pastures on their farms in Tanzania, as well as working on the Kagera River Basin Project–Transboundary Agro-ecological Systems Management project, funded by FAO. He has worked closely with pastoralists on research in pasture improvement in pastoral and agro-pastoral livestock production systems. He has worked collaboratively with international institutions such as the International Livestock Research Institute (ILRI) and CIAT, and higher learning institutions like Sokoine University of Agriculture (SUA).

Peter KULAKOW is a cassava breeder/geneticist with IITA. He obtained his BSc and PhD degrees, both in genetics, from the University of California, Davis. Prior to joining IITA, he was an environmental consultant and research assistant professor in agronomy at Kansas State University. He has extensive experience in plant breeding, environmental science, and project management, including 8 years with the Land Institute in Salina, Kansas, and 13 years with Kansas State University. He has also worked as a consultant in landscape ecology with the University of Nebraska.

Ben LUKUYU is an animal nutritionist researcher specializing in feeds and feeding of ruminant and non-ruminants, and currently serves as ILRI's country representative in Uganda. He has a wealth of experience in livestock production systems, developing and implementing sustainable innovations to improve livestock value chains. His research work is dedicated to productivity-enhancing research projects aimed at transforming animal nutrition research outputs into wider use by various actors in livestock value chains. His interest has gradually expanded to integrating livestock into smallholder crop livestock production systems. In addition, he developed the training program for the Feed Assessment Tool and promotes its use amongst different stakeholders for targeting and developing feed interventions. He has worked collaboratively with institutions of higher learning, international and local research organizations, government departments, not-for-profit organizations, private sector, and community-based organizations. He has worked extensively with smallholder farmers in ESA, West Africa, India, and Pakistan.

Tessy MADU is a social scientist with a PhD in rural development works with NaCRRI–Umudike, Nigeria. Her remit includes gender-responsive research in root and tuber crops in Nigeria as well as research into farming systems of southeast agro-ecological zones of Nigeria and how to improve them.

Walter Edward MANGESHO is a senior livestock researcher and ag. manager of livestock technology transfer at Tanzania Livestock Research Institute in Tanga. He is responsible for innovation and knowledge management and technology dissemination with great experience in innovation platforms and value chain approaches. He has 10 years of experience in livestock-related research, including working on different national and international projects using different approaches, such as innovation platforms, value chain analysis, and business hubs, to bring smallholder farmers on board and involve them in the planning and implementation of the research activities. His engagement is illustrated by many relevant publications and reports. He holds an MSc in tropical animal production and a BSc in animal science from SUA.

Catherine MEOLA is a development sociologist working as an independent consultant on gender, agriculture and environment. She has worked as a gender specialist for the International Center for Tropical Agriculture (CIAT), the International Center for Research on Women (ICRW), and the Food and Agriculture Organization of the United Nations (FAO). Currently, she provides technical assistance on gender integration at the Inter-American Development Bank (IDB). She holds a PhD from Cornell University in Development Sociology.

Clare MUKANKUSI is a scientist and a bean breeder working for CIAT under PABRA. As a regional breeder she provides major support to the East and Central Africa Bean Research Network, working hand in hand with fellow breeders in the national agricultural research systems (NARS) who are heavily engaged in bean variety development processes such as PVS. She is based at the CIAT–Uganda offices that are housed by the Uganda National Agricultural Laboratories, Kawanda, where she develops and tests new breeding populations and lines for pest and disease resistance, drought tolerance, high iron and zinc grain content, cooking time, and canning quality. She maintains bean germplasm at the lab in Kawanda that she sources from CIAT's headquarters in Colombia, NARS partners in Africa, and other agricultural research institutes worldwide and makes them fully accessible to all bean researchers in Africa. She is involved in training of NARS partners and young researchers within the PABRA region in common bean breeding and pathology.

She has authored papers on bean root rots in particular and co-authored publications on other bean diseases, drought tolerance, biofortification, bean seed systems, and agronomic studies on common beans. She coordinated the project “Participatory Evaluation of Common Bean for Drought and Disease Resilience Traits in Uganda,” which was implemented in 2012/2013 under the support of the CRP on Climate Change, Agriculture and Food Security.

Mary Gorreth NAMUDDU is a food scientist working with NARO—Uganda. She has been at the forefront of sensory evaluations of *matooke* hybrids in Uganda. She uses qualitative and quantitative tools to match farmers’ perceptions and aspirations to new banana varieties. A GREAT Project Fellow from Theme 1, she holds a BSc in food science and nutrition from Makerere University.

Baloua NEBIE has worked as a sorghum breeder at ICRISAT–Mali since January 2013. His research in the West and Central Africa Regional Sorghum Improvement Program focuses on genetic resource utilization and participatory breeding of hybrids and OPVs, including multipurpose sweet-sorghum and biofortified varieties. He holds a PhD (2014) and MSc (2009) in genetics and plant breeding from the University of Ouagadougou, Burkina Faso. He has authored and co-authored more than 15 articles in various domains, including breeding, agronomy, and modeling.

Esther NJUGUNA-MUNGAI is a social scientist currently working as the gender specialist for ICRISAT’s East and Southern Africa program. She is coordinating a portfolio of research that seeks to understand the gender yield gap; women’s participation in agricultural value chains; interface between gender research, women, and crop breeding processes; gender norms; and capacity enhancement for gender research implementation in SSA. She has been working with male and female smallholder farmers since 1996. She holds a PhD in agricultural development and economics from the University of Nairobi and an MSc in agricultural development from the Wageningen University and Research Centre.

Stanley NKALUBO is the national legumes program coordinator and a bean breeder/geneticist for NARO, where he has worked since 2006. Based at NaCRRI–Namulonge he provides leadership of bean research and related development interventions for Uganda organized under five areas of focus: plant breeding and genetics, plant agronomy, seed systems, social sciences including gender, and capacity building. He is actively involved in breeding for common beans with the aim of producing new varieties that are resilient to the changing environmental conditions, with high iron content and great market demand. His research also focuses on assessing and finding practical breeding solutions and approaches to crop production constraints that directly affect the sustainability of the livelihoods of resource-poor families. To date, he has bred and released for commercial purposes 14 bean varieties, 5 of which are of high iron content with short-maturing properties as compared with local checks. He also contributes to training and mentoring of postgraduate students and/or young scientists in partnership with local universities, especially Makerere University.

Patrick OKORI is the current country representative for ICRISAT–Malawi and is a groundnuts breeder, leading breeding programs in the ESA region.

Olamide OLAOSEBIKAN is a consulting gender specialist with the Cassava Breeding Unit at the International Institute of Tropical Agriculture (IITA), Ibadan. A PhD research student in the Department of Agricultural Extension and Rural Sociology, University of Ibadan, she specializes in gender and agricultural development studies. Her research explores gender sensitivity in agricultural research and how research activities are transforming the livelihood of rural people.

Melanie RAMASAWMY conducts research on women and chicken husbandry in Ethiopia focuses on the role of chickens in the household and their relationship with gender, status, and the domestic economy. This was followed up by post-doctoral research in Ethiopia on the “Going Places” project—a collaborative project between Roehampton, Nottingham, Leicester, and Oxford universities—and the African Chicken Genetic Gains project. She has a PhD in anthropology from the University of Roehampton; her previous research, as part of an MSc in anthropology and the ecology of development from University College London, focused on small-scale sugar cane farming in Mauritius.

Fred RATTUNDE has worked as a cereal breeder for the past 30 years, working on oats, rye, pearl millet, and sorghum. He and Eva Weltzien, who jointly were awarded the 2015 Justus-von-Liebig World Nutrition Prize, guided the ICRISAT–Mali Sorghum Breeding Program in West Africa for 18 years. During this time he, together with national partners, developed the first sorghum hybrids based on local Guinea-race germplasm and supported farmer participatory breeding and seed production activities. He is a freelance consultant and honorary associate at the University of Wisconsin-Madison.

Losira Nasirumbi SANYA is a research officer in-charge of planning, monitoring, and evaluation at NARO–Uganda. Her research interests are in agricultural innovation systems, including value chain development and gender responsiveness of agricultural systems and how these stimulate technology uptake. She is a fellow of the GREAT project, Theme 1 on roots, tubers, and bananas. She is also a GREAT Sub-Saharan Africa Gender Specialist Fellow and a member of the GREAT Community of Practice Advisory Board. She holds an MSc in agricultural economics and a BA in social sciences from Makerere University, Uganda, and is currently pursuing a PhD in agricultural and rural innovation.

Moses SIAMBI is currently the research program director of ICRISAT’s ESA program. During its implementation he was the regional agronomist and country representative for ICRISAT–Malawi.

Felix SICHALI is an agribusiness specialist who has spent more than 15 years working on agricultural projects, and is currently a project manager with ICRISAT–Malawi. He coordinates operations of the Malawi Seed Industry Development project, which aims at improving legume and cereal seed systems and complementary agricultural innovations to catalyze productivity improvement and associated social benefits of improved food, nutrition, and income security to smallholder farmers. Prior to joining ICRISAT he worked for NASFAM, serving in various managerial positions (e.g., agribusiness development coordinator, business development manager, and national operations manager—agro-inputs). He earned his MSc in strategic management from the University of Derby (UK).

Mamourou SIDIBÉ, scientific officer in the Sorghum Breeding Program at ICRISAT–Mali, has worked extensively in participatory on-farm research over the past 15 years. He has an MSc in rural development.

Hermann SOMÉ is a statistics and data management specialist currently working with the West and Central Africa Council for Agricultural Development (CORAF/WECARD) as a technical coordinator of Integrated Breeding Platform to support West African breeders integrate their breeding data in to BMS. Prior to joining CORAF/WECARD, he was scientific officer, statistics and data management at ICRISAT–

Mali. He received his MSc in biostatistics from the Laboratory of Biomathematics and Forest Estimation University of Abome–Calavi Benin and an MSc in applied statistics from Sub-Regional Institute of Statistics and Applied Economics, Yaoundé, Cameroon.

Reuben Tendo SSALI is a plant breeder associate with CIP and previously worked as a senior research officer with NARO–Uganda. He has been breeding East African Highland bananas for high yields and pest and disease resistance for 15 years. He has been involved in various innovations along the banana-breeding pipeline while generating banana hybrids and evaluating their performance and response to pests and diseases to select the most promising hybrids. He is a GREAT Project Fellow from Theme 1 and holds a PhD in plant pathology from Stellenbosch University, and an MS in crop science and BSc in botany, both from Makerere University.

Béla TEEKEN is a gender postdoctoral research fellow at IITA with an interdisciplinary background in rural sociology and plant physiology. At IITA he works closely with the cassava breeding unit to develop gender-responsive breeding through participatory and interdisciplinary approaches. He worked briefly with the nongovernmental organization Sristi, in India, on grassroots innovations. His PhD (Wageningen University) research combined social and natural sciences and investigated the interactions between socio-cultural, genetic, and ecological factors within farmer rice seed selection and development in West Africa, which included fieldwork in the Togo Hills in Ghana and Togo.

Aboubacar TOURÉ has more than 25 years of experience working as a sorghum breeder in Mali, Puerto Rico, and Texas. He is currently the team leader for the Sorghum Improvement Program at ICRISAT–Mali, and previosuly served as program officer for crop improvement and variety adoption at the Alliance of a Green Revolution in Africa, as coordinator of the West and Central Africa Sorghum Research Network, and as principal sorghum breeder at Institut d'Economie Rurale–Mali. He has developed and released several new white-seeded, high-quality sorghum cultivars and hybrids for Mali and other West African countries, and has experience in germplasm collection, enhancement, conservation, and training. He holds a PhD in plant breeding from Texas A&M University, and has published several scientific articles and book chapters related to sorghum crop improvement.

Hale Ann TUFAN is a principal investigator of the Gender-Responsive Researchers Equipped for Agricultural Transformation (GREAT) project. A molecular biologist by training, she has worked for the John Innes Centre, the International Maize and Wheat Improvement Center, and the University of East Anglia, School of International Development. Hale joined International Programs, Cornell University, in 2012 to manage the NextGen Cassava breeding project. For the project she developed the NEXTGEN Cassava "Gender-Responsive Cassava Breeding" initiative to capture needs, priorities, and challenges women and men face in cassava production, and to prioritize gender traits in breeding program design and implementation. Her current research focuses on linking qualitative cassava trait descriptors with breeding and food science variables on-station.

Eva VAN DEN BROEK received her MSc degree in rural development sociology at Wageningen University and Research Centre, the Netherlands. She conducted a field study on Malian women's engagement in sorghum production and notions of and approaches to gender within development interventions while at ICRISAT as part of her MSc thesis. She has worked for Médecins Sans Frontières since 2014 as human resources and finance administrator in India, Central African Republic, Syria, Afghanistan, Haiti, and (at present) the Democratic Republic of Congo.

Kirsten VOM BROCKE is a scientist at the Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD) integrated in the research division "Genetic Improvement and Adaptation of Mediterranean and Tropical Plants." Her main experiences are in PPB and seed systems in West Africa, where she has worked with international (ICRISAT) and national (Burkina Faso and Mali) research institutes and farmer organizations. She is now managing and integrating participatory approaches in the high-altitude, upland rice breeding program of the national research institution in Madagascar (FOFIFA).

Eva WELTZIEN worked on the improvement of dryland cereals in tropical and subtropical regions over the past 35 years, focusing on the effective use of sorghum, pearl millet, and barley genetic resources for variety development and seed systems that respond to farmers' needs and production opportunities. Her research and training efforts, emphasizing farmer participatory breeding tools and approaches, were conducted in Syria, North West India, Mali, and other West African countries. She had worked at ICRISAT for 28 years and now is a freelance consultant and honorary associate at the University of Wisconsin-Madison.

APPENDIX A: EVALUATION CRITERIA

1. Study clearly maps to a step in the breeding cycle diagram
2. The research is clearly focused on generating information for application in breeding
3. One or more of the gender research dimensions below is addressed in the study:
    - Roles/responsibilities
    - Opportunities/constraints
    - Access/control of resources
    - Preferences/practical and strategic needs
    - Decision-making power
    - Cultural norms
    - Gendered benefit/cost differentials
    - Gendered participation
    - Differences in knowledge
    - Community leadership
4. Sex-disaggregated data and analysis
    - If yes, is the sex-disaggregation utilized in the analysis?
    - Is it discussed in the findings?
5. Type of data
    - Quantitative versus qualitative
    - Intersectionality: Are contextual gender norms and other social divisions and conditions discussed?
    - Are there sufficient data from both men and women?
6. Do the findings, conclusion, and discussion include take-aways and (research, program, or policy) recommendations that add to design principles for gender-responsive breeding programs?

The CGIAR Gender and Breeding Initiative brings together plant and animal breeders and social scientists to develop a strategy for gender-responsive breeding with supporting methods, tools and practices. The Initiative includes experts from across CGIAR centers and Research Programs, is coordinated by the CGIAR Research Program on Roots, Tubers and Bananas and the International Potato Center, and is supported by CGIAR Funders.