11 Gendered technology adoption and household food security in semi-arid Eastern Kenya

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Introduction

Hunger and malnutrition are scientific and moral problems that lie at the root of most other global development challenges, since malnutrition effectively blocks development and achievement across generations (Kavishe 1995). In Kenya, agriculture is the cornerstone of the economy. It employs millions, feeds more, and has a multiplier effect in that farming supplies raw materials to, and supports, many other industries. Small-scale farming (on plots averaging 0.2–0.3 hectares) dominates food production in Kenya, pointing to the importance of directing research and development efforts towards smallholder and subsistence farming systems (Hickey et al. 2012).

Because most agricultural production takes place at the household level, gender relations are central to understanding both how the farming system works and the extent to which initiatives to build resilience in the farming system (e.g., in relation to project research activities) support equity and improve food and nutrition security. Men and women in various types of households may make separate and autonomous decisions, as well as joint decisions, on important matters such as adoption of new agricultural technologies and practices. These decisions have implications for who provides the labour and who reaps what rewards of that adoption. For example, it has been shown that when women control income, they generally allocate a higher percentage to food, health, clothing, and education for their children than men do (FAO n.d.). As a result, a better understanding of the gendered division of household labour is an essential component of enabling household food provisioning and the marketing of agricultural products through agricultural innovation systems capable of supporting resilience.

One premise on which this study was grounded is that food insecurity is closely related to inequitable household power relations, within which women lack sufficient access to, control over, and use and ownership of livelihood resources (Meinzen-Dick et al. 2011), including the elusive assets of time and mobility. As a result, better understanding of where

such inequities lie may help identify ways in which research can better contribute to overcoming barriers to resilient household food and nutrition security.

Literature review/theoretical perspective

Many authors have observed and measured gendered differences in the adoption of agricultural innovations and technologies (Sanginga et al. 1999; Doss and Morris 2001; Tiruneh et al. 2001; Kinkingninhoun-Mêdagbé et al. 2010). Constraints to innovation adoption among women include risk aversion, insecure access to as well as land and other natural resources, labour, credit, research, and extension; poor or poorly implemented policies; and insufficient knowledge sharing and joint action among key actors (Quisumbing 1996; Ogunlana 2004; Eidt et al. 2012). Differences in culturally and socially constructed food customs, economic interactions, and mobility also impact women's capacity to adopt. Historical and geographical differences further add to the overall complexity of research on adoption of agricultural innovations to address food insecurity.

In addressing the specific dilemma of women's *not adopting* agricultural innovations at the same rates as men, our analysis considered both on-farm household decision-making and the scientific research methods employed by agricultural researchers. This study sought to better understand the adoption cycle from the household perspective, with an examination of *what* is being "offered" for adoption; *how* it is introduced; and *what women do adopt*, under what terms and conditions, and *with what results* for household food security. The findings have practical and conceptual implications, suggesting mechanisms for supporting household and community resilience by identifying ways in which barriers to women and men farmers' adoption of resilience-building agricultural innovations can be lowered.

Since our study examined the dynamics of adoption in relation to the achievement of improvements in food security, it was of central importance that *what* was included for adoption in the study was capable of improving food security outcomes and measures. While this may seem like an obvious point, it is important to state it directly because a segment of the literature on adoption of agricultural innovations does not explicitly assess the food security outcomes of the technologies under consideration, but focuses on return on investments, both at farm and stock market levels. Scholarly discussion of adoption of agricultural innovations is strongly rooted in econometric analyses of the diffusion of technologies arising through the Green Revolution (Feder and Umali 1993). Much focus has subsequently been placed on casting adoption as a determinant of economic growth, and on understanding adoption decisions in terms of risk assessment, profitability, and the spread or diffusion of "modern" technologies (Feder and Umali 1993; Teklewold et al. 2013; Fisher and Kandiwa 2014). Recognising that economic growth alone is not a reliable indicator of household food security,

the scope of the study also considered other values and benefits accrued by farmers in the adoption cycle, chiefly nutritional, social, and ecological.

Gender analyses have clearly demonstrated that power is frequently unequally distributed among farm household members. This can be seen in inequities in control over resources, and in unequal division of labour and benefits (Alderman et al. 1995). The fact that women suffer higher rates of malnutrition and hunger than men – "twice as many women suffer from malnutrition as men, and girls are twice as likely to die from malnutrition as boys" (FAO n.d.) – further highlights the inadequacy of "increased farm product profitability" as a singular solution to hunger and malnutrition among all household members (see also Quisumbing 2003; Brownhill et al. 2016). In the Kenyan context, the promotion of cash cropping has at times diverted natural and financial resources from women's to men's control, sometimes leading to women's reluctance or even resistance to engage in adoption (Turner et al. 1997).

The dominant drive in development and research is towards the commercialisation of farming. This shifts the focus of many studies away from actual health outcomes and other non-priced benefits of innovation adoption, such as improved ecological well-being and social capital. Some studies do consider non-priced benefits, but separately – for instance, studies on the ecological benefits derived from adoption of particular production techniques (Terry and Khatri 2009). The present study extended such analyses to examine an integrated range of non-priced values (e.g., dietary diversity) associated with an integrated set of technologies and farm practices, in order to better understand what women and men consider and value when they make decisions about innovation adoption.

Scholarship on the centrality of women to agricultural development in general, and to the achievement of food security in particular, has spurred a turn in the adoption literature to include more attention to gendered patterns of adoption (Doss and Morris 2001). While female-headed households are widely understood to be more food insecure than male-headed households (Kassie et al. 2014), and while men tend to adopt new agricultural technologies more robustly than women (Doss and Morris 2001; Peterman et al. 2010), there remains some definitional confusion about how to distinguish male and female activities within farming households (Appleton 1996; Ragasa 2012). Doss's influential 2002 study on gendered cropping patterns in Ghana argues that "few crops can be defined as men's crops and none are clearly women's crops", a finding that flies in the face of common perceptions about the crops that women and men prefer, and from which they reap benefits. Doss addresses a key limitation of her study, which does not count women farmers who "farm for household consumption on plots held by men" or whose "individual plots may contain crops for which different individuals claim ownership rights" (2002: 1999). These categories of women comprise a significant proportion of female farmers, and their exclusion from analysis has important implications for understanding the gendered patterns of agricultural labour.

Doss et al. elaborated on the distinctions among households, in particular with regard to land ownership: "When only household-level data are collected, researchers do often compare the landownership patterns of male- and female-headed households. However, this approach may underestimate women's landownership by ignoring the land owned by women in male-headed households" (2013: 4). Such analyses provide a useful caution against generalisations concerning women's and men's rates of adoption and crop preferences. They also indicate a need for more in-depth consideration of the relations among women and men in the specific households under study. This was addressed by including categories of male-headed, female-headed, and male-headed–female-managed households in the data analysis, as well as considering overlapping entitlements, such as wives' power over gardens on land owned by their husbands.

This chapter acknowledges the negative impact of inequality, in particular in the way that, in silencing or sidelining women's knowledge and preferences, inequality impoverishes dialogues and debates on local solutions to hunger and malnutrition. Drawing women back into the discussions of science, technology, development, and policy likewise enriches the debates. In particular, a gendered analysis offers insight into women's adoption preferences, their capabilities to choose, and the sometimes hidden and undervalued benefits that they, and their children, derive from their subsistence-informed farming decisions. Our intent was to contribute to "unblocking" existing adoption pathways, in ways that complement and strengthen efforts to improve women's access to resources. Women's priorities and preferences (as well as men's) were used to inform next steps (e.g., in research directions and policy recommendations) to increase women's adoption of food and nutrition security-enhancing agricultural innovations. During the three-year study, the need also arose to clear new pathways (for adoption, information, enterprise) through the less-charted territories connecting women's farming preferences with priorities in science, development, policy, and the market.

The analytical lens used here focused on both "non-adopting women" and those who promote the innovations: the local and international researchers, development officials, funders, and policymakers. By including a focus on those promoting technologies and other innovations for farmer adoption, this analysis addressed the extent to which research, development, and policy have been sufficiently informed by women's preferences, interests, capacities, and expertise. In the process, the authors drew self-reflectively on their own experiences in a participatory research project, both to assess the outcomes of the research in terms of women's rates of adoption of innovations, and to contrast their methodology with others that are less fully guided by gender transformative and farmer-led approaches.

As important as the question of the food security merits of what is promoted for adoption are the questions of what methods of diffusion are employed, and with what potential benefits, for whom. These questions recognise the long history of agricultural and environmental interventions in

Kenya in general, and in the eastern counties in particular (Tiffen et al. 1994; Ifejike Speranza et al. 2008). Colonial initiatives in the 1930s and 1940s accomplished the terracing of thousands of miles of hillside in Machakos by enforcing compulsory labour among villagers in the vicinity, who were mainly women, as men were engaged in migrant labour (Tiffen et al. 1994). A good "innovation" was thus introduced in a top-down, punitive manner that engendered serious resistance.

At other points on the spectrum are soil conservation initiatives, and development efforts of all kinds, that are founded on participatory principles, differentiated by their varied goals, methodologies, and outcomes. Indeed, it was in a Kenya Agricultural Research Institute (KARI) partnership study of soil conservation efforts in Kenya that researchers developed the participatory learning and action research (PLAR) model to engage community knowledge, interests, and "ownership" of conservation practices (Defoer 2002; Eksvärd and Björklund 2010). The present study focused on both the *whats* of adoption (evaluating the food and nutrition security contributions of the innovations) and the *hows* (both in terms of research design and implementation, and in terms of farmers' day-to-day adoption activities), to assess food security outcomes in relation to the project's objectives and methodology.

The research sought to identify means by which both women and men farmers can empower themselves to adopt resilience-building agricultural innovations. The study was thus organised specifically to work with farmers to select the resilience-enhancing practices and technologies they want to evaluate as methods of addressing their own households' food and nutritional security needs. These local solutions and empowerment objectives are based on the scientific understanding that the social relations that support food and nutrition security are characterised by equity (Njuki and Sanginga 2013), diversity (Kumar 2002), and prioritisation of the reproduction of ecological conditions to allow for continued production (Shiva 2013) as well as inheritance by younger generations (Muriuki 1974).

Theoretical framing

In light of unsettled debates over men's and women's crops and land (Doss 2002; Doss et al. 2013), and over the importance of farm income to household food security strategies, an important conceptual starting point for this study was the recognition of the tensions and overlaps between subsistence and market-oriented farming systems.

Subsistence and smallholder farming systems are the starting places for the majority of Kenyan farmers. The project's participatory approach revealed that the semi-arid farming systems are surprisingly robust. This is true especially in light of the condition of the surrounding support systems, including extension, infrastructure, and markets, which require as much, or more, improvement and innovation as farming practices. More precisely,

improvements to the farming system (through adoption of resilient technologies and practices) will perhaps succeed to the extent that extension and markets serve the development and maintenance of the nutrition and income value chains that this system might sustain.

The research was likewise guided by an eco-feminist perspective, which considers gendered and ecological intersections in examining food security concerns. This transformative gender approach, with its recognition of research "subjects" as active agents of innovation, finds methodological expression in Cooksey and others' insistence on two-way dialogue in research and development and, moreover, "webs of communication" among key actors (Vogel et al. 2007; Cooksey 2011). The results of the adoption survey were analysed in a step-wise tracing-out of who does all of the activities and makes the decisions in farm families' efforts to adopt farming innovations.

A few caveats must be added here. The crops being evaluated in the project were all high-value traditional crops, and while some had higher market demand and cash value than others, and some were more preferred as foodstuffs than others, all shared both income and nutritional benefits. None could be said to be only and purely a cash crop, and in fact, all of the crops evaluated by farmer groups in the project can be referred to as high-value traditional crops, such as sorghum, millet, green gram (mung beans), and cowpeas, which are typically women's preference and domain.

One effect of this choice of "typical subsistence" crops to be evaluated in the project is that the distinction between cash and food crops was not as strongly present as it would have been in a different setting. Mango and pawpaw (papaya) were included in the survey and analysis of findings; although they were not among the crops promoted for adoption in the project, they are important to the local farming systems in these semi-arid agro-ecological zones. They also provide a point of contrast to the high-value traditional crops that were more central to the project's overall goals. While sorghum and millet are valuable food crops, mango and pawpaw are typically market-oriented crops controlled by men, and the patterns of decision-making and division of labour and benefits are likewise strongly skewed in favour of men. These contextual factors are discussed further in the following sections.

Methodology

The project

The "Innovating for Resilient Farming Systems" food security research project, funded by the Canadian International Food Security Research Fund (CIFSRF) and implemented in Kenya by KARI and McGill University, facilitated farmer evaluation and adoption of a range of components of resilient farming systems in three semi-arid counties of Eastern Kenya: Tharaka-Nithi, Makueni, and Machakos. The research focused on an integrated

assessment of social, economic, knowledge-based, institutional, and policy factors that impact farmers' ability to adopt socially and ecologically resilient farming system practices and technologies. These technologies drew on local resources, and included indigenous crop varieties and poultry breeds, as well as those varieties and practices developed by agricultural research institutes and government extension services. The general objective of the project was to contribute to improved food security among women and men in hunger-prone communities, by improving the conditions for sustained farmer adoption of resilience-enhancing farming practices.

Because of the context that it provides for the discussion of the survey that generated the data analysed in this chapter, a brief review of the methodology employed in the research project of which this particular gendered adoption study was a part is presented. The project's activities were undertaken in the lower midland (LM), lower humidity to semi-arid (LM4) and semi-arid (LM5) agro-ecological zones (AEZs), where 600–800 mm of annual rainfall is distributed in two peak seasons (March–May and October–November). Farmers in these AEZs typically combine subsistence food and livestock production under conditions of only moderate intensity of land use.

A combination of high-value traditional food crops (early-maturing or drought-tolerant varieties) and integrated practices including soil fertility, water harvesting, and livestock and pest management practices, were evaluated by and with smallholder farmers using an adaptation of the "mother and baby" trial design (Snapp 2002), termed primary participatory agricultural technology evaluations (PPATEs). In the PPATEs (equivalent to "mother" trials), farmers in selected groups grew, evaluated, and compared two or three varieties of eight different resilience-enhancing crop types. Members of the PPATE groups shared their knowledge with members of other farmer groups (secondary participatory agricultural technology evaluations (SPATEs), equivalent to "baby" trials) through a mentoring relationship, whereby secondary group members picked a subset of technologies that they found most attractive from the PPATE group evaluation set. The project engaged the participation of a total of 54 PPATE groups and 216 SPATE groups representing over 5,000 farmers.

As a result of this focus on farmer learning in the adoption process, adoption was reconceptualised as part of a cycle of farmer innovation, involving a triple-A cycle – analysis–action–assessment – through which farmers made daily and seasonal decisions (Kavishe 1995).

While taking direction from this change-oriented model, the three steps of the triple-A cycle were also modified to more fully represent the seasonal activities of farming. The three steps identified were *adoption*, *adjustment*, and *adaptation*. These steps completed the model's representation of the cycle of farm-level decision-making and activities concerning changes in farming practices.

The basic premise is that *adoption* requires some *adjustment* of the farmers' practices and work patterns. The success of these adjustments leads to

adaptation of the farming system to be more resilient in the face of the climatic and socioeconomic conditions that farmers face. In iterative fashion, these adaptations feed back into further decisions and actions on adoption (of the same, new, or additional innovations), with subsequent further adjustment of farming practices, leading to deeper or more resilient adaptive capacity. Within the process of adjusting farming practices to meet the needs of the adopted innovation, it was noted that it is largely women's agricultural labour and related resources that undergo "adjustment".

The project's view of adoption as a seasonal cycle complemented its analysis of the household-level links on the agricultural value chains that bring crops from field to plate. These chains may take products to local or regional markets, and then to consumers' kitchens and tables; or they may channel food from the farmer's field, to their granary, and to their table directly, constituting an on-farm nutritional value chain. In either case, the people who inhabit or activate each link in a crop's value chain are identified, and the many overlaps among the several value chains that farmers pursue are examined. Thus a complex matrix of value chains, which represent both priced and non-priced values, forms the households' integrated farming system and wider livelihood system.

We attempted to nuance the analysis by teasing out the gender relations at different points in the adoption cycle and in the larger diversity of value chains, and from there assessing ways forward for gender equity in household food and nutrition security. It is important to recognise that market value chains are developed within a context of the enterprises' many other benefits, including direct household food consumption, and concomitant non-priced benefits of health, nutrition, ecological well-being, and the potential for youth employment generation. In this study, concepts of *local* value chains, and of *nutritional* value chains, expressed the intention to maintain a focus on these wider benefits of adoption not only for women, but for their communities and ecologies in general.

The gender survey

After five seasons of evaluation in the PPATE groups and three seasons in the SPATE groups, the gender research stream conducted a survey to assess the impacts of, and gender dynamics at play within, the adoption decision process. Households were sampled from the PPATE and SPATE groups in the three counties, while a set of randomly selected non-project households were also included in the sample for comparison. A total of 405 households were sampled. Tables 11.1 and 11.2 summarise the sample, by farmer group membership type and by head of household (male-headed, male-headed–female-managed, and female-headed).

The survey incorporated questions on adoption, resilience, labour, asset ownership, nutrition, and management of indigenous chickens (a project innovation). This chapter reports mainly on the results concerning adoption.

Table 11.1 Households differentiated by the way they participated in the KARI/McGill University Food Security Research Project

Farmer group membership type	*Machakos*	*Makueni*	*Tharaka-Nithi*	*Total*
PPATE	59	73	55	187
SPATE	51	65	20	136
Non-project farmer	23	36	23	82
Total	133	174	98	405

Table 11.2 Number of households surveyed in each county, by type

	Machakos	*Makueni*	*Tharaka-Nithi*	*Total*
Male-headed and -managed	92	111	77	280
Male-headed–female-managed	14	34	9	57
Female-headed and -managed	25	29	12	66
Child/orphan	2	0	0	2
Total sample surveyed				405

The main disaggregating factor was the set of "who" questions: who benefits from various income streams; who participates in various tasks; who owns assets in the household; and who makes decisions over those assets. To assess the impacts of the project interventions, the questions were based on two time frames: before (2011) and after (2014) project implementation.

Results

Survey respondents

Among the respondents to the gender survey, 280 of the households were headed and managed by men; 57 were male-headed but female-managed, since the men lived away from home for a substantial number of months per year, leaving the women as *de facto* heads of household; and 66 households were *de jure* female-headed. Two households, in Machakos, were orphan-headed; because there were so few, they were not included in the statistical analysis.

Seed access by the respondents

The gender survey sought to understand the adoption cycle from its inception: where farmers get seeds (source, indicating the different trading centres), who is responsible for obtaining seed for the family, and how far

from their homesteads the household members have to travel to obtain seed. The number of sources was highest for the male-headed and -managed households, who reported 16 options in Machakos, whereas the female-headed households (both *de facto* and *de jure*) indicated that they had only 4 to 7 options.

In terms of the distances covered in sourcing the appropriate seeds, Machakos farmers presented an interesting example. Across the sample, women reported having a smaller radius of mobility, measured in terms of how far they travelled to source seed. But in the Machakos sample, where the female-headed households reported covering an average of 4.9 km to source seed, and male-headed households covered 13 km on average, the members of male-headed–female-managed households covered an average of 20.2 km. This may be explained by the fact that the men from these households work in distant towns where they may be able to access seed and remit it to their families.

All farm household types in the sample reported an increase in the amounts of drought-tolerant or early-maturing seeds that they were planting after participating in the project (Table 11.3). The biggest gains were seen in the amount of green gram seed that farmers bought. Green gram is a crop that has a high demand among traders for retail sale to consumers in urban areas of Kenya, and occasionally as an export commodity to Asian countries. Farmers in the three counties were growing green gram as a cash crop more than they were using it for household consumption.

Adoption of, and labour provision in, different crops

The next objective was to find out who initiates the choice of crops to plant in a season, and who provides the labour for ploughing, planting, weeding, harvesting, and marketing farm produce.

The results generally showed that men are the main decision-makers when it comes to choice of enterprises and marketing of the produce in the survey sample. This became especially prominent in the permanent and market-oriented crops like mango and papaya. Even in female-headed households, where one might expect the women to make most decisions, it seemed there were male relatives who were influential in the decision to plant mango and pawpaw. Although there was a degree of collaboration in labour provision between men and women, women in all the household types provided considerably more labour than men in planting, weeding, and harvesting. However, there was a clear difference among the women who participated in the project as members of PPATEs: the PPATE women participated more in the marketing stage compared to SPATE members and non-project members. Women in the male-headed households appeared to have much less decision-making power and participation in labour provision in the different production steps when compared to women in *de facto* and *de jure* female-headed households.

Table 11.3 Amount (in kg) of drought-tolerant, early-maturing seeds planted by different types of farm households before and after participating in the project

	Male-headed and -managed				*Male-headed–female-managed*				*Female-headed and -managed*			
	Before		*After*		*Before*		*After*		*Before*		*After*	
	N	*Mean*	*N*	*Mean*	*N*	*Mean*	*N*	*Mean*	*N*	*Mean*	*N*	*Mean*
Maize	250	12.05	245	13.91	49	15.67	50	8.9	62	13.17	61	9.39
Sorghum	139	2.99	132	3.5	29	3.05	26	2.73	32	3.38	30	2.73
Millet	72	3.66	70	3.79	10	3.95	11	4.86	17	3.27	13	3.62
Green gram	220	5.08	217	6.33	42	5.8	46	8.45	58	4.43	58	4.86
Cowpeas	220	4.41	221	5.48	45	4.93	49	4.97	59	4.63	58	4.29
Pigeon peas	199	3.85	206	4.26	36	4.48	39	4.68	54	3.27	52	3.31
Dolichos	46	2.11	65	3.1	21	2.98	26	2.56	16	1.3	17	2.07
Beans	183	9.12	165	11.54	29	8.38	26	7.19	46	8.47	41	8.59

Participation in farmer groups

Farmer groups have been identified as an important avenue for agricultural knowledge dissemination within communities. The respondent households were therefore asked if both men and women belonged to farmer groups. Up to 50 percent of women in the PPATE and SPATE categories were members of farmer groups, some participating in up to six different groups. In contrast, fewer than 20 percent of men and women in the non-project farmers' category were members of a farmer group. Farmers in this category miss out on a number of opportunities to learn about innovations in the agricultural sector, and to give and receive mutual support for farming and related activities. These missed opportunities are reflected in household food security status.

In all categories in the household sample, women participated in groups more than men. This likely emphasises the social capital that women often build, maintain, use, and rely upon to strengthen their capacities to engage in labour as well as to compensate, to some degree, for lack of access to key assets through sharing of labour and resources.

Food security improvement

The ultimate goal of the project was to improve the participants' food security status. A proxy for food security in the study was the number of months per year of sufficiency in the provisioning of food for all members of the household. Respondents were asked to compare the period before and after the project. Among the PPATE farmers, the number of households reporting a shortage of food decreased for all months after the project. Among the SPATE farmers, the number of households without enough food decreased slightly in the period after the project. Among the non-project farmers, there were several months (May, June, September, and November) when more people did not have enough food (see Figure 11.1).

Discussion

By disaggregating gendered patterns of engagement along the range of activities that follow initial "adoption decisions", the research showed that the men in the survey sample contributed to decision-making more than to labour in the adoption cycle, and, moreover, that men's share of decision-making power over allocation or use of income was greater than both their labour contribution and their participation in initiating the adoption of the chosen technology. These findings support previous research suggesting that men benefit far more from crop income, and therefore from women's labour, than do the women themselves (Sorenson 1996; Turner et al. 1997).

Income is not the only measure of value in the agricultural product value chains, nor in farmers' adoption decisions. Feeding the family directly from

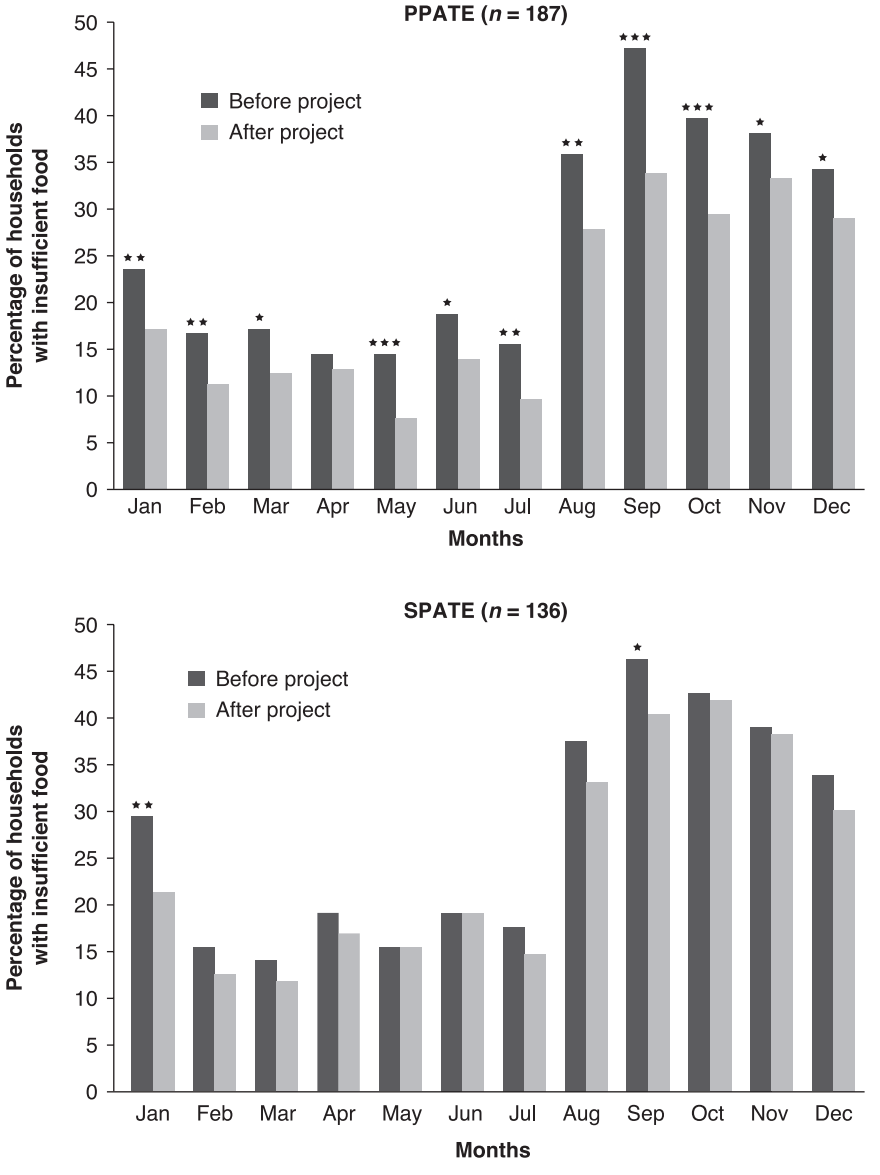


Figure 11.1 Percentage of households with insufficient food before and after the KARI/McGill project

Key: ⋆⋆⋆ P < 0.01; ⋆⋆ P < 0.05; ⋆ P < 0.10 (McNemar Test; one-tailed test).

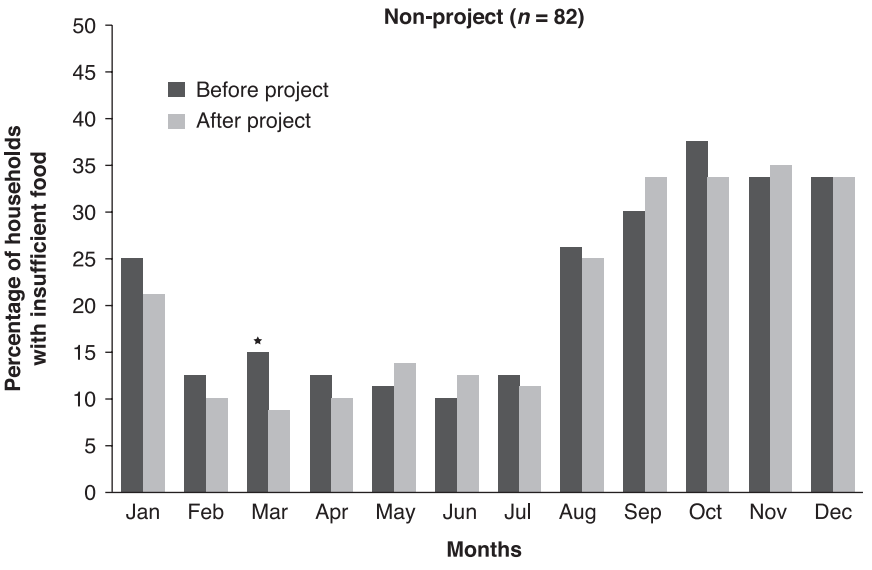
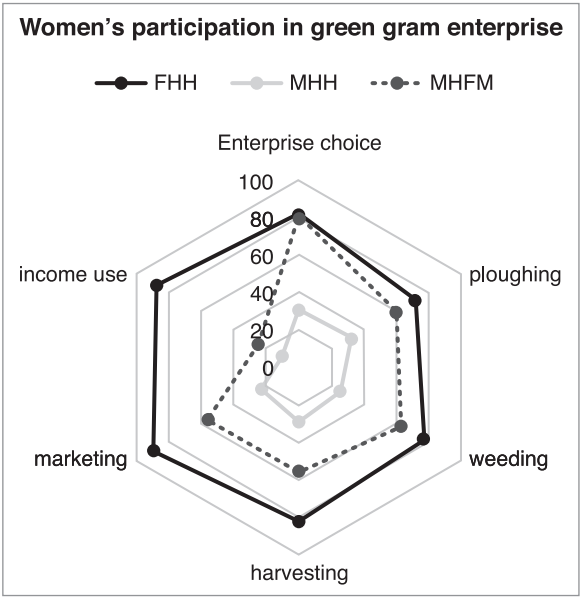


Figure 11.1 (Continued)

the farm is the prime example of a non-priced benefit that is of immense value in any adoption calculations farmers may make. Moreover, a review of the non-priced benefits of given agricultural innovations reveals a set of "in-kind" contributions to household food security, which in the end may be more important to, and more within the control of, women than the narrowly defined value of a cash income. The study turned to the dynamics of these priced and non-priced benefits to explore gendered adoption decisions, and some of the food security outcomes of those decisions.

The anticipated finding was that women preferred one type or set of crop(s) and that men preferred others, and that the food security impacts and outcomes would also differ between genders. What was found instead was a more nuanced gendered pattern in the adoption decision-making process (see Figure 11.2). Depending on household type, and on type of farmer group membership, women in the sample displayed considerable power in introducing both traditional "food" crops and "cash" crops, in terms of both sole decision-making and joint decision-making with spouses or other adult male relatives. At the same time, when it came to the implementation of "adoption" (jointly derived on-farm innovation decisions), inequalities re-entered the gendered division of labour in the production, sale, and share of consumption of particular crops (e.g., cowpea, green gram).

Joint decision-making did not, in the sample surveyed, lead to an equal division of agricultural labour. In adjustment of on-farm activities to accommodate the adopted innovations, women took on the bulk of these changes.



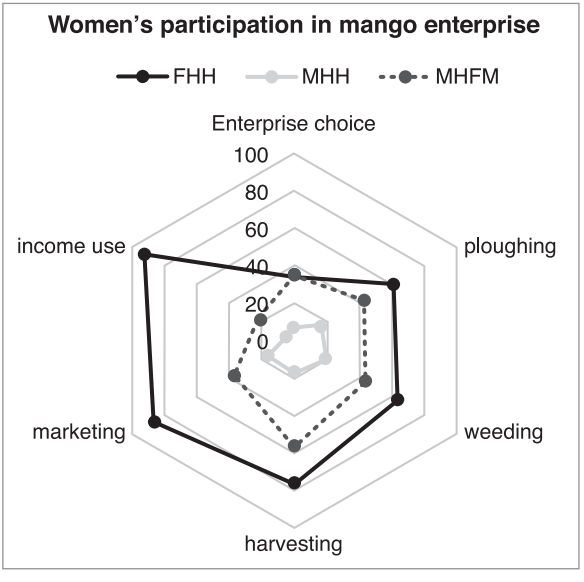


Figure 11.2 Analysis of women's participation in the various steps in selected enterprises categorised by whether the household is male-headed, male-headed–female-managed, or female-headed

Key: FHH: female-headed household; MHH: male-headed household; MHFM: male-headed–female-managed household.

In terms of other values gained and reinforced in the process, socio-cultural, ecological, and nutritional benefits were shared generally across the households of those associated with the project's evaluations, with those most closely aligned with project farmer groups reaping greater gains than their counterparts less centrally involved in the project. The adaptations made included a greater diversity of income and food sources, inputs into natural resource management, and greater household food sufficiency.

The research findings identified a gendered complexity of on-farm adoption processes, and suggested measures capable of assessing complex innovation decisions and activities over time. Researchers' assessments would benefit from taking into account not only the moment of decision, but the entire adoption cycle through which the decision to adopt leads to adjustments of the farming system. To the degree that *what* is adopted and *how* it is implemented contribute to resilience, the cycle results in socioecological adaptations in response to shocks and uncertainties.

The adoption cycle and the subsequent development of local value chains are constituted by a complexity of highly gendered decisions, resource allocations, and livelihood activities. With this understanding, the questions of non-adoption and dis-adoption are also illuminated because the balance of women's decision-making may be more tightly tied to the whole adoption cycle than has previously been credited. In other words, women's decision-making on adoption is firmly grounded in their experience of various crops' successes and failures, and their balancing of resources, time, and labour to contribute to their households' daily subsistence (Ashraf et al. 2009). The existence of both market and nutritional value chains may make an important difference to women, whose access to market income is limited, but whose control over food in the granary is nearly complete.

Given women's historically low rates of agricultural innovation adoption, debate continues over how best to increase women's participation in, and share of the benefits from, particular scientific knowledge production processes. The project addressed this question by focusing on a range of crops and farming practices that women had ranked as highly preferred. As a result, two goals were achieved: gains in a range of measures of household food and nutrition security, and the reversal of women's non-adoption trend – *when something they had chosen and prioritised* was the subject of study.

In conjunction with adoption of women's preferred crops and farm management practices, group work offers a socially networked pathway towards improving household food security. Examination of the adoption cycle inquired into group membership to confirm what others have also found, namely, that group membership accelerates adoption (Abebaw and Haile 2013; Ramirez 2013; Kassie et al. 2014). There is much less attention in the literature, however, to how adoption, supported by group membership, in turn further contributes to maintaining and building social networks as a non-priced benefit that is especially valuable to women. During the project period, social networks were reported to have strengthened through a

number of avenues, including training in dietary diversity and the formation of marketing opportunity groups to aggregate and negotiate produce prices with marketers. These positive steps are in line with what other scholars have noted: that "in order for development interventions to succeed, strategies must clearly rely on, and take cognizance of, local 'social capital' and the indigenous skills possessed by communities" (Nel et al. 2000: 26).

Farmers are agents of innovation and have experimented for generations to create most of the tremendous stock of seed varieties known to the world (Fowler and Mooney 1991; Kloppenburg 2004). Their agency is seen in their creativity, and also in their critiques, as farmers sometimes actively resist scientific interventions that "would seem like impositions or even as active attempts to 'convert' [farmers] to [the scientists'] way of thinking" (Cooksey 2011: 287). Resistance to adoption of agricultural innovations can point to a mismatch between the scientists' and farmers' views on what is a "successful", "proven", or "effective" technology, or between the scientists' and the farmers' expectations and resources. This mismatch is evocative of the inequities often found between women and men within households, and may contribute to the problem of low rates of farmer adoption of agricultural innovations.

The study of gendered adoption processes also brought to light a "missing link" in the local agricultural product value chain, that is, smallholder and subsistence farmers' links to local markets. This recognition points to a need to better support and develop Eastern Kenya's widely networked market system for locally preferred agricultural products to move the potential supply of, and demand for, healthy, nutritious, local grains, legumes, and produce. Among the households surveyed, what has been referred to as the *radius of women's mobility* appeared to impact women's adoption decisions, from sourcing of seed to their access to and control over market relations and transactions. Based on the research results, the scale and scope of trade most likely to empower women is the "walkable distance", suggesting that a multi-level strategy including trade that takes place within women's typical radius of mobility, with attention given to the sociocultural specificities of each local place, could be beneficial. The results also support the need for policies that not only promote local market development but also protect them from policies and programs that impede, weaken, or crowd out small-scale private-sector actors within these local markets.

Women's access to markets and income could also be increased by widening women's radius of mobility and expanding their resource ownership (e.g., land and vehicles). But these changes are not easily articulated in policies or implemented in programs, given the extent to which they require changes in intimate day-to-day livelihood activities and relations between husbands and wives, youth and elders, in culturally diverse households and communities. These kinds of changes bring development researchers into the realm of deeper social, cultural, and legal transformations that are perhaps more legitimately the purview of the Kenyan citizens and state. Research by

Kenyans and by international scientists can inform debates on such changes, and provide recommendations for policy and programming; but, for the time being, external agencies' efforts are better directed at strengthening existing institutions, such as women's and farmer groups, and market and extension networks.

And, while this participatory research project initiated some progress in terms of engaging farmers in processes of prioritising and evaluating the innovations under study, the research team could have gone much further in the direction of having its studies guided by women's expressed interests. Indeed, the analysis goes some way towards arguing that if Kenya's food security-related science and policy were more fully guided by women's preferences, then not only would adoption by women increase, but, more important, women's adoption of innovations that strengthen equitable, resilient, and food-secure farming systems could be expanded to a larger scale.

Conclusion and recommendations

The gendered dynamics of adoption identified in this research suggest that a longitudinal study of the further patterns involved both in adoption cycles (including innovation decisions at the "adjustment" stage) and the larger development of local agricultural product value chains (including market and nutritional chains) could help track changes in decision-making, food security measures, and overall farming system resilience (Andersson and D'Souza 2014). Such a study could provide insight into the extent to which the predominance of women's labour power in new enterprises feeds into renewed adoption and innovation decisions (decisions to continue with, localise, or drop an enterprise) season after season, and in turn how different patterns may result in women's greater or lesser power and benefits in ecological, nutritional, and income terms (Devereux and Longhurst 2010). These questions arise from, but lie beyond the scope of, the present study.

This chapter has examined the outcomes of a participatory research project in Eastern Kenya and assessed how gendered technology adoption practices impact the advancement of food and nutrition security goals. In focusing on the rationale behind women's adoption decisions, the researchers discovered a key driver of adoption in "non-priced values" (e.g., nutritional, ecological, institutional, educational), and located innovative measures of women's empowerment in group organisation and marketing in the geographic niches most soundly associated with the radius of mobility that women typically enjoy.

Where the geographic scope of market activity lies within a woman's typical radius of mobility, the benefits of that enterprise are less likely to be usurped by men, who have significant sway over the mobility of the female members of the household. Strengthening enterprises within the geographic settings most favourable to women's participation could also lay the groundwork for a densely networked development of post-harvest handling,

processing, and onward transportation of products that could potentially fill an enormous need for youth self-employment in agricultural livelihood systems. The development of *local* agricultural value chains has greater potential to empower women financially than larger-scale or farther-flung market networks (Gurung 2011). Policies for *multi-level* development of food markets could then advance the empowerment of women and youth through income, healthy local food distribution, and youth employment. This further indicates the potential advances in household food security to be made by taking greater guidance from the direction of women's adoption decisions, as well as their rights, entitlements, resources, and knowledge, such that what is promoted for adoption is more closely tailored to meet women farmers' values, preferences, and mobility.

Non-priced values complement other drivers of adoption, including income generation; but the non-priced values are not wholly reducible to or replaceable by cash income. The nutritional, ecological, or cultural values provided by one crop may not be replaced by the money earned through growing another crop. Thus, non-priced values may either compete with or complement "priced" market values. The study findings suggest that the *diversity of benefits* beyond the income potentialities of the adopted technologies is one key to understanding gender dynamics in the farming system, as farmers test and evaluate resilience-enhancing innovations.

It has been noted that women are more likely to adopt enterprises with which they are familiar, to which they are accustomed, and which they already may be practising (and seeking to adopt new practices). But it has also long been noted that whether pursuing women's engagement in a traditionally male livelihood activity (such as goat rearing) or improvements in a typically female pursuit (such as cultivation of diverse varieties of bananas), when money begins to flow, men tend to become more interested in taking over the marketing aspect of the activity (Gurung 2011). The "non-priced values" that women and their households share, such as nutritious food, gifts, and compost, are concrete benefits from the adoption of particular enterprises which, it can be argued, partially explain women's adoption (and non-adoption) decisions.

Recommendations for policy and research include focusing on local agricultural value chains, multi-level market development, and recognition of the diversity of benefits and values, both priced and non-priced, that men and women bring to, and enjoy from, the implementation of their adoption choices. Proportionate emphasis can be given, in research, development, and policy priorities, to understanding and promoting the non-priced nutritional, ecological, and sociocultural outcomes of agricultural technology adoption initiatives. This would help to improve women's and children's health, nutrition, and food security, objectives that are foundational to the achievement of all other development goals.

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