


Sustainable and equitable agricultural mechanization? A gendered perspective on maize shelling

Gundula Fischer , Bekele Kotu and Christopher Mutungi

Africa RISING, International Institute of Tropical Agriculture (IITA), Arusha, Tanzania

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Author for correspondence:

Gundula Fischer,
E-mail: g.fischer@cgiar.org

Abstract

How can agricultural mechanization be accomplished in a sustainable and equitable way? This question has gained increased prominence in mechanization research over the past few years. In this study, we apply the question to mechanized maize shelling in Tanzania as a case in point. Data from a survey with 400 farmers and from semi-structured interviews with 21 key informants are combined for a gender analysis that relies on Kabeer's concept of four institutional sites (household, community, market and government). The findings reveal that although mechanization reduces men's and women's perceived drudgery of shelling, relief depends on gendered patterns of labor allocation and decision-making at the household level. As a result, the transformation of inequitable norms emerges as paramount. Key informants identified additional aspects that would make mechanized shelling more equitable and sustainable, such as mainstreaming gender and mechanization in comprehensive agricultural training, or the sensitization of mechanized input suppliers and manufacturers to farmers' preferences (including gender-sensitive machine design). Concerted efforts in multiple institutional sites are needed to achieve lasting change in respect of equity in mechanization.

Introduction

In recent years, publications on agricultural mechanization in sub-Saharan Africa have increasingly asked how mechanization can be achieved in a sustainable and equitable manner across entire value chains (Sims *et al.*, 2016; Sims and Kienzle, 2017; Kormawa *et al.*, 2018). This question accompanies agricultural intensification investments geared at raising productivity to meet the globally growing demand for food. Past efforts at mechanizing production are evaluated as having addressed only certain labor steps, most often land preparation, misconstruing tractors as drivers of economic change instead of viewing them as tools, as Pingali criticizes (2007). This selective approach can be seen as one component of broader neglect of farmers' demands, including insufficient investigation of women's and men's differential constraints, needs and labor burdens (Diao *et al.*, 2016; Sims *et al.*, 2016). Questions of equity have tended to focus narrowly on how mechanization may shift or limit employment opportunities for certain social groups (see for instance Pingali, 2007). It does not come as a surprise that reviews of mechanization efforts often fail to take into account the gender dynamics that shape mechanization processes and their outcomes.

Mechanization experts expect that emphasis on the following three aspects will promote sustainability: First, stakeholder participation in situation analysis and planning is seen as essential for establishing a demand-driven and context-specific process (Houmy *et al.*, 2013; Sims *et al.*, 2016). Second, 'a holistic view of agricultural mechanization' and examination across the value chain is suggested (Kormawa *et al.*, 2018, p. 93). This entails paying attention to post-harvest losses and value addition to make mechanization commercially more viable. Third, 'gender issues should be considered and main-streamed in all aspects of mechanization development' (Sims and Kienzle, 2006, p. 47). This should include gender analysis, measures to ensure that mechanization contributes positively to women's empowerment and the design of gender-responsive mechanization technologies and training programs (Sims and Kienzle, 2006; Kormawa *et al.*, 2018). Recent gender studies already provide insights into cases of mechanization, such as tractors (van Eerdewijk and Danielsen, 2015; Kansanga *et al.*, 2019), forage choppers (Kiyimba, 2011; Fischer *et al.*, 2018), reaper harvesters (Theis *et al.*, 2018, 2019), and groundnut shellers (Orr *et al.*, 2016).

This article examines the mechanization of maize shelling in Tanzania from a gender perspective. Although project reports have documented the spread of this technology over the past few years (Kahan *et al.*, 2014; Joel, 2017; FAO and AfDB, 2019), a literature search has not produced any social science investigation of this topic. Kahan *et al.* (2014) argue that the current dissemination of the technology can be explained by the rising import of farm machinery since 2009 following the government's Kilimo Kwanza initiative. Especially two-wheel tractors

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have become more common. They are used with supplementary equipment for various operations including maize shelling. Furthermore, development interventions have promoted small engine-powered or bike-mounted shellers (Matheson, 2015; Joel, 2017; Gasper *et al.*, 2017). The objectives of these interventions are to limit post-harvest losses, to improve grain quality for the market, to reduce drudgery, and to raise the productivity and the income of farm households. Analysis of the gender dynamics surrounding the technology's application constitutes a gap in research, a gap that is addressed in this article. Kabeer's concept of institutional analysis (1994) has shaped the line of inquiry and will be introduced below.

Conceptual framework

In her seminal book 'Reversed Realities' (1994), Kabeer establishes four key institutional sites for conducting a gender analysis within her Social Relations Framework: market, community, government and household. Each institutional site comprises rules (official and unofficial laws and norms), patterns of resource distribution, patterns of inclusive or exclusive group formation and activities, and relations of authority and control. Kabeer sees the household as the 'logical starting point' of the analysis, since it plays a key role in enabling or constraining its members' participation in economic and social processes (1994, p. 283). However, gender inequality as a whole is constituted by interactions between all four institutional sites. Similarly, changes toward more equity in one location may lead to repercussions in the other locations. For this reason, attention must be paid to different institutions and their interconnectedness in the development process. Imbalances related to gender, age, marital status, ethnicity, wealth or other stratifying criteria frequently overlap and influence each other. This focus on intersectionality and the interaction between scales (or sites) resonates well with studies that have applied a feminist political ecology lens to mechanization (Kansanga *et al.*, 2019, 2020).

Investigations into gender and agricultural mechanization provide examples of the distribution of resources, responsibilities and power in each institutional site, and of relations between sites. In the *household* site, women's often limited voice in decision-making hampers the articulation of their demand for mechanization in men-headed households (MHHs). Men's prominence in decisions on labor—including who does what and using which methods (manual or mechanized)—are associated with their high levels of income control and land ownership (van Eerdewijk and Danielsen, 2015; Fischer *et al.*, 2018). Having their own land and income can be a 'gamechanger' for women. But gendered labor norms, such as the ideal of a 'good hardworking wife,' still render requests, or the fulfillment of requests, for female labor relief unlikely, since mechanization would be seen as allowing women to become 'idle' (van Eerdewijk and Danielsen, 2015; Kansanga *et al.*, 2019). Theis *et al.* (2019) observe that unmarried women sometimes have more freedom to employ technical implements, as they are viewed as going against social norms anyway. Where women's manual tasks are appropriated by men as soon as they are mechanized, this can have mixed outcomes: women may appreciate being relieved of a burden, but at the same time they face a new dependency on male cooperation in order to get their work done (Orr *et al.*, 2016; Fischer *et al.*, 2018). Men's fascination for mechanized tasks and equipment is explained in terms of the symbolic power and masculinity they gain from them. The ability to use and own

machines underlines men's position as decision-makers (Kawarazuka *et al.*, 2018; Kansanga *et al.*, 2019).

Mechanization efforts on the part of NGOs and government extension services frequently overlap in the *community* and *government* institutional sites. Where mechanized technologies are offered to farmers' groups, the latter tend to be composed of more men than women for various reasons: policymakers tend to conceptualize their target groups on the basis of household headship and land ownership, thus cementing the image of 'the farmer' as male (Farnworth and Colverson, 2015; van Eerdewijk and Danielsen, 2015). Women's high domestic labor burden and the belief that women have less technical competence lead to processes of biased selection or self-selection for training courses (Fischer *et al.*, 2018). As a result, women farmers acquire less knowledge of machines and how to implement mechanization in their individual households or through collective action (van Eerdewijk and Danielsen, 2015). Development actors who seek to relieve overburdened women through technical equipment, and do not concomitantly address gender relations, as well as interactions between institutional sites, may experience unexpected results (Kiyimba, 2011). Ladipo (1991) describes the case of a Nigerian women's cooperative that had to sell its project-funded maize sheller and return to manual processing. This happened after men in the community had opposed their wives' initiative and seized the machine.

In the *market* institutional site, social norms may restrict women's direct market engagement. In this case women need to access mechanization services through intermediates (even when they use their own income). However, unrestricted female market access is also documented (van Eerdewijk and Danielsen, 2015; Kawarazuka *et al.*, 2018; Theis *et al.*, 2018). For a variety of reasons, it may be difficult for women to take up roles as entrepreneurs or employers in the field of mechanization services: as compared to men, they often have lower levels of training and experience with technical equipment and less access to financial resources to buy implements (a condition that can be attributed to patterns of resource distribution and group formation in the household and community sites). Furthermore, they are faced with stereotypes of being 'naturally' less technically competent and less able to exert the authority necessary for such roles (Theis *et al.*, 2018). Finally, male-biased machine design can discourage women from operating implements and shows a disregard for them as customers (Kiyimba, 2011; Fischer *et al.*, 2018; Kawarazuka *et al.*, 2018).

In the *government* institutional site, Kormawa *et al.* (2018) observe that greater consideration of women and youth issues is needed in agricultural mechanization strategies. Moreover, gender analysis should raise the awareness of public extension workers and result in more conscious efforts to build the mechanization capacity of women. The above examples of processes and conditions in various institutional sites yield selective insights and vary remarkably in different contexts.

The line of inquiry in this paper follows Kabeer's approach. In the first step we investigate the history and context of mechanized maize shelling in Tanzania. We look at our respondents' experiences of mechanization and the patterns of groups that use and operate maize shellers. In the second step, we take the household as a starting point to carve out men's and women's labor roles and perceptions of drudgery in respect of maize cultivation and post-harvest processes, with a focus on manual *vs* mechanized shelling. Additionally, we analyze features of household decision-making with regard to shelling. In the third step, we broaden the inquiry

Table 1. Basic socio-economic characteristics of survey respondents

Respondent category	Men heads (<i>n</i> = 196)	Women in MHHs (<i>n</i> = 115)	Women heads (<i>n</i> = 80)	<i>F</i> -value
Age (mean, years)	47.17	40.01	52.95	20.225**
Education (mean, years)	6.08	6.20	4.38	9.079**
Household size (persons)	6.28	6.43	4.51	20.339**
Annual household income (mean, USD)	792	630	453	3.415**
Machine users (%)	73.8	73.0	66.2	$\chi^2 = 0.426$
Respondent category	Machine users (<i>n</i> = 284)	Non-machine users (<i>n</i> = 115)	<i>t</i> -value	
Age (mean, years)	45	49	2.401*	
Education (mean, years)	6.11	4.83	3.385**	
Household size (persons)	6.13	5.46	2.557*	
Annual household income (mean, USD)	779	400	4.396**	

*** shows statistical significance at 5% and 1% levels, respectively.

to include extra-household institutions. We explore suggestions made by stakeholders in multiple sites for changes that would promote more equitable and sustainable mechanization.

Materials and methods

For this study, a mixed-methods approach was chosen. It consists of a survey whose results were validated and supplemented by semi-structured interviews with key informants. The data were collected between April 2017 and December 2018. The last validation of results with key informants took place in 2019. The survey covered 400 households in three districts in central and northern Tanzania (Kongwa, Kiteto and Manyara districts), resulting in 391 complete cases for gender analysis. A structured questionnaire had been prepared for a broad investigation of post-harvest processes in maize production, including gender aspects. The households were selected randomly from five village household lists. We interviewed one person per household, in approximately half of the cases adult men (mostly the head, 196 cases) and in the remaining cases adult women (115 spouses and 80 heads). The selection of one person per household limits insights into intra-household processes such as decision-making, where interviewing men and women from the same households would have yielded more results. The decision to interview a man or a woman was based on prior random assignment. Using a lottery approach, we determined whether in a given household a male or female adult household member should be interviewed. In a few cases, an interview with a male respondent was assigned to a woman-headed household. These cases were substituted by other randomly selected respondents. In a strict sense, this constitutes a bias, since the small group of men living in women-headed households was not considered. However, the focus on only three respondent groups (men heads, women in man-headed households and women heads) can be justified by the low number of male spouses in Tanzanian women-headed households and the high presence of female spouses in MHHs (Øvensen, 2010). At the beginning of the interview, respondents were requested to self-identify their position within their household. The disaggregation by sex and household position that underpins much of the analysis in this article is based on respondents' self-indicated position.

The enumerators and supervisors were trained for 5 days on the subject of the study, survey techniques, the establishment of a

gender-sensitive interview setting and the application of e-survey tools. In all cases, women enumerators interviewed women farmers. This approach eased access to women respondents living in MHHs (where heads often act as gatekeepers, see Randall *et al.*, 2011) and created a conducive set-up for sensitive questions such as who makes decisions. In addition to the survey, we conducted interviews with 21 key informants (7 women, 14 men) located in Arusha and Dodoma, as well as in the districts in which the survey was implemented. The interviews included asking the respondents to establish activity profiles for maize cultivation and post-harvest processes. Key informants were purposively chosen (partly through snowball sampling). Survey data were analyzed with SPSS. Semi-structured interviews were transcribed and analyzed with Atlas.ti.

Table 1 provides a basic sample description of survey respondents. It shows that women heads tended to be older than other respondents. The mean level of education was below the completion of primary school (7 years). With an average of 4 years of schooling, women heads had the least formal education. They also indicated a lower annual household income than respondents living in MHHs. Differences in levels of household income between men and women in MHHs can be explained by the fact that male and female respondents belong to different households. However, it must be taken into account that information on income is often not shared between spouses in the study context, with men tending to indicate higher incomes (Fischer *et al.*, 2020). Differences between machine users and non-machine users will be presented in the section History and context of mechanized maize shelling.

The sample of 21 key informants consisted of maize shelling entrepreneurs (four men), agricultural engineers (two women), one woman agricultural mechanic, one male agro-dealer, extension officers (five men), one male representative of the Small Industries Development Organization (SIDO), one male machine manufacturer and representatives of farmers' groups (four women, two men) who run maize shelling machines under the group ownership model.

Results

History and context of mechanized maize shelling

Key informants spoke of roughly two waves of maize shelling mechanization, one which started in the late 1980s and a second

beginning around 2010. Earlier, in the Socialist period (lasting from 1967 to the mid-1980s), the Tanzanian government had placed emphasis on animal-powered mechanization, but with a focus on tillage (Mrema, 1984). Simple imported manual maize shellers had been offered in the market as early as the late 1970s, but had experienced little demand (Mothander *et al.*, 1989). Toward the end of Socialism, efforts increased to locally assemble and manufacture tractors, with a first factory being set up in 1981 (Mrema, 1984). In the same year, the government established the Centre for Agricultural Mechanization and Rural Technology (CAMARTEC), one of its objectives being to develop and disseminate implements for post-harvest mechanization.

During the first wave of shelling mechanization in the late 1980s, large-scale farmers acquired tractors for land preparation. After harvest, they operated shelling equipment through power take-off. Having shelled their own maize, they began to offer services to others, preferably those with higher volumes of produce. To this day tractor-run shellers are common, but respondents described them as few in number and as mainly found in easily accessible rural areas. A manufacturer of agricultural machines in Kongwa characterized most of the large-scale farmers operating maize shellers as men who employ groups of young male laborers. 'Male' jobs include supervising the machine, lifting bags to feed the hopper, keeping machine outputs clear and loading bags of shelled maize for transportation. Jobs such as packing maize cobs into bags or vessels in preparation for feeding the machine or cleaning the grain after shelling, are often left to women. Men respondents explained this division of labor as being based on the perception that working with shellers demands physical strength, high levels of attention, quick reactions and precise physical work. They saw young men as most likely and women as least likely to have these capabilities. However, some respondents also said that men used to and still do claim a priority right to employment opportunities. At this point, labor demands become linked to notions of masculinity and favor young men's access to income.

Key informants' narratives hint at various developments that led to the second, much broader, shelling mechanization wave that began around 2010 and coincides with the government's Kilimo Kwanza initiative to transform and commercialize Tanzanian agriculture. An expansion of agriculture combined with the increased use of improved seeds created a demand for post-harvest mechanization. At the same time, the growing number of mechanics and local manufacturers benefited from the spread of electricity. They began to engage in the fabrication of agricultural equipment, such as small shellers which are operated with portable engines and can be carried on oxcarts or motor-cycles. A different group of shelling entrepreneurs emerged: people who employ these machines to serve small-scale farmers, including some in remote villages. A woman agricultural engineer explained in the interview: 'There are women who run these shelling businesses, but they are not in the front line of operation. They will employ men.' Other respondents confirmed the persistent belief in men's 'superior' operation skills, but saw it challenged by a (slowly) growing number of women mechanics who have graduated from vocational training centers and development interventions promoting gender-sensitive mechanization (such as the USAID-funded 'Innovations in Gender Equality' program).

How does this historical sketch relate to farmers' general experience of mechanization in the study area? Respondents reported that they had most experience of mechanization in relation to motorized and animal-drawn land preparation methods

for the cultivation of maize (56.6%), cowpeas (14.7%), groundnuts (9.6%) and roots and tubers (9.2%). Before the interview almost all respondents (99.4%) had either seen or heard about motorized maize shellers. In terms of actual use, more than a quarter had never used the machine (26.2% of the men, 27.0% of women in MHHs and 33.8% of the women heads). Differences between respondent categories are statistically not significant. Several key informants mentioned a correlation between income and machine use for all household types, namely less machine use by low-income households. This is confirmed by the survey (Table 1) where machine users had on average higher annual household incomes (US\$779 vs 400), were younger than non-users (45 years vs 49 years) and had more years of schooling (6.11 years vs 4.83 years)—all results being significant at 1–5% alpha level. Kiteto had the highest number of machine users (86.3%), followed by Babati (70.3%) and Kongwa (58.8%). The lower number of users in Kongwa could be due to the more pronounced cultivation and consumption of sorghum and millet in this district as compared to the other districts (for regional differences, see URT, 2017). Most respondents (71.3%) had employed the machine for the first time in the 3 years preceding the study (2014–2016). A few individuals dated their first mechanized shelling activities back to 1982. It is against this background that we examine gender dynamics at the household level below.

The household institutional site: labor and decision-making on maize shelling

During the survey we requested participants to score the drudgery they associate with various maize-cultivation and post-harvest activities. For each activity, we provided ten beans, one bean standing for least tiresome and ten beans for most tiresome. Respondents associated the weeding of maize with most drudgery, women indicating higher scores than men (Table 2). Harvesting scored second for women, whereas men assigned the second position to land preparation. The process of maize shelling ranked only sixth for women and seventh for men. However, the mean value masks important differences in the experience of drudgery for shelling-machine users and non-users. Those who shell manually rated the activity with a score of 6.98. They perceived the drudgery involved as almost equal to weeding (the most tiresome activity of all). Machine users assessed shelling as less labor-intensive (2.96) and similar to drying unshelled maize in the homestead; it ranked tenth in terms of drudgery. Differences in perception of the drudgery involved in shelling between machine users and non-users are significant at the 1% level. Why shelling-machine users also had significantly lower perceptions of the drudgery of land preparation as compared to non-users would need further investigation. One explanation could be that shelling-machine users (who have a higher income, see the section History and context of mechanized maize shelling) generally make more use of mechanization options, including those for land preparation. This underlines the importance of assessing mechanization across related agricultural operations in future research.

To explore whether a gendered division of labor is linked to perceptions of drudgery, we requested key informants to establish activity profiles for unpaid household labor. The profiles consisted of the list of labor steps presented in Table 2, but with a distinction between shelling by hand, by beating with a stick, or by machine. For each step, respondents indicated which of the following social groups tend to engage in it: adult men, adult

Table 2. Drudgery scores for maize cultivation and post-harvest activities (ranking in the whole process indicated in brackets)

Respondent category/Labor steps	Men heads	Women in MHHs	Women heads	F-value	Shelling machine users	Shelling machine non-users	t-value	Total
Maize cultivation								
Land preparation	5.20 (2)	4.97 (4)	4.72 (5)	0.972	4.78 (3)	5.67 (3)	3.026***	5.04 (2)
Planting maize	4.72 (4)	4.68 (5)	5.03 (3)	0.568	4.71 (4)	4.77 (4)	0.215	4.77 (4)
Fertilizer/manure application to maize	4.95 (3)	3.95 (7)	3.56 (7)	9.509***	4.25 (6)	4.59 (6)	1.157	4.39 (6)
Weeding maize	6.34 (1)	7.46 (1)	7.78 (1)	18.282***	7.01 (1)	6.77 (2)	1.017	6.96 (1)
Harvesting of maize	4.59 (5)	5.06 (2)	5.25 (2)	2.963*	4.86 (2)	4.59 (5)	0.986	4.85 (3)
Post-harvest processes								
De-husking of maize	4.42 (6)	4.98 (3)	4.83 (4)	1.898	4.70 (5)	4.55 (7)	0.554	4.67 (5)
Transport of unshelled maize to homestead	3.84 (8)	3.56 (8)	3.53 (8)	1.056	3.63 (7)	3.81 (8)	0.839	3.70 (8)
Drying of unshelled maize in the homestead	3.13 (10)	3.04 (9)	2.64 (10)	1.484	2.89 (10)	3.23 (9)	1.574	3.02 (10)
Shelling of maize	3.91 (7)	3.98 (6)	4.66 (6)	1.883	2.96 (9)	6.98 (1)	14.141***	4.08 (7)
Drying of maize after shelling	2.69 (13)	2.02 (13)	2.06 (12)	3.815	2.32 (13)	2.51 (13)	0.842	2.43 (13)
Transport of shelled maize to storage	3.54 (9)	2.71 (10)	2.56 (11)	10.923***	3.13 (8)	3.00 (10)	0.588	3.10 (9)
Grain management in the store	3.10 (11)	2.61 (11)	2.66 (9)	3.199**	2.89 (11)	2.81 (11)	0.399	2.87 (11)
Grain marketing	2.98 (12)	2.03 (12)	2.01 (13)	15.137***	2.43 (12)	2.79 (12)	1.619	2.53 (12)

***, ***, * show statistical significance at 10%, 5% and 1% alpha levels.

women, boys, girls, adolescents or the elderly. Respondents were free to select multiple options for each step. The results show no strict gender division of labor in maize cultivation, except for the following tendencies: men (including young men) were reported to engage more in land preparation. Harvesting, de-husking and shelling by hand were more frequently seen as tasks for women and children than for men. Shelling by machine, as well as the transportation of unshelled and shelled maize, emerged as 'male jobs' with high involvement of young men. These tendencies are partly reflected in the survey's drudgery scores, as for instance in men's higher scores for the transport of shelled maize and women's more pronounced perception of harvesting as drudgery. In another survey question, we requested respondents to focus exclusively on the drudgery involved in different shelling methods. No matter what method, men found shelling generally more tiresome than women, as the mean rank on the drudgery score in Table 3 shows.

In the survey, we asked respondents how they had shelled their maize in the last season (Table 3). The most common method was the machine, followed by beating with a stick and hand shelling. There were no significant differences between respondent categories, except for the stick, which women heads (55.4%) had used more than women in MHHs (45.2%) and men heads (36.4%). Respondents may use various shelling methods for different parts of the same harvest, as key informants mentioned. Apart from avoiding shelling costs, there are three other reasons why farmers may decide to shell part or all of their harvest manually. First, in the lean period (preceding the new harvest) some farmers may have run out of food stocks and have no available income to purchase food. This leads to reaping immature or insufficiently dried maize which they shell by hand. Often machine shelling services are not yet available at this time of the year and if they are, the shelling of moist maize results in high levels of grain damage. Second, farmers who cannot afford to buy improved seeds fear

that mechanized shelling will cause grain breakage, and manual labor makes it possible to monitor the quality of their recycled seeds. This job is mainly done by women. Third, women farmers may have an interest in using the maize cobs as fuel after having removed the grain. Sometimes, female hired laborers are given the cobs as part of their payment for manual shelling. Some shelling machines (especially the larger tractor-driven ones) tend to break cobs and are therefore less popular with farmers. All of these aspects may influence men's and women's choice of shelling method and can be assumed to be more critical for low-income farmers.

As Table 2 reveals, respondents see a sharp reduction in drudgery through mechanized shelling. Renting a machine, hiring labor for shelling or even buying a shelling machine, can bring relief. In MHHs, however, decisions to do so are highly men-dominated (Table 4). Men reported that they took the majority of decisions alone or jointly. They consistently rated their own decision-making power as higher than that of their wives. Women in MHHs ranked joint decisions first, husbands' decisions second, and their own decisions last. A regression analysis of the same data proved (Kotu *et al.*, 2019) that where more active female labor was available in households, willingness to rent a shelling machine decreased (significant at 5% level), while a relationship with the availability of men's labor was not found.

Key informants confirmed men's high decision-making power; they linked this to land ownership, income control and to the perception that looking for machine services or for hired labor requires leaving the domestic domain, to which women tend to be more restricted. They also spoke of new trends toward more joint decision-making, which are not reflected in the quantitative data. The question of how men and women construe joint decision-making can be considered only briefly but would merit further data collection. Key informants described two gender norms in this respect which—although contradicting each

Table 3. Unpaid household labor: methods of shelling and mean rank drudgery score by gender and household position

	Men heads, <i>n</i> = 179	Women in MHHs, <i>n</i> = 112	Women heads, <i>n</i> = 80	
Method of shelling (% of respondents)				χ^2 value
Hand	10.4	10.6	13.9	0.336
Stick	36.4	45.2	55.4	6.008*
Machine	85.2	90.2	86.3	1.179
Mean Rank Drudgery Score				<i>F</i> -value
Hand	8.94	8.63	8.39	4.056*
Stick	7.94	7.38	7.30	5.236**
Machine	2.44	1.67	1.73	13.756**

*** show statistical significance at 5% and 1% levels, respectively.

other—both underline men's authority. First, women should not preempt their husband's suggestions. As soon as men have made their proposals, their wives are expected to support them. Women who speak first may be seen as 'unfittingly' attempting to dominate their husband. Second, a woman may make suggestions to her husband. However, in all cases, he is taken as the final decision-maker in a joint process. Apart from this, a few respondents also mentioned households in which important agricultural decisions are considered as concerning not only the adult couple but the whole family and are taken at family meetings (*vikao vya familia*). As a result, the response variable 'joint decision-making' in the survey has to be interpreted with care, since the data do not reveal whether it involves actual negotiation or consists only of informing others about unilateral decisions mainly taken by men (see Acosta *et al.*, 2020). Further insights into intra-household processes are limited by the fact that only one person per household was interviewed.

If we look at who engages in shelling for payment, we see that 71 respondents in the sample (18.6%) had shelled maize for other households, 51 of them were men. In 75% of all cases, hired laborers used the machine for shelling, followed by the stick. This is in line with the activity profiles key informants established for hired labor. Shelling by machine (and to a lesser extent by beating with a stick) and transporting of unshelled and shelled maize were reported as paid jobs most likely to be done by men (with strong involvement of young men). Women were perceived as being engaged in paid shelling by hand more than in shelling by stick or machine.

Other institutional sites: envisioning equitable and sustainable mechanization

Household labor and decision-making provided the starting point for the analysis of gender dynamics surrounding maize shelling. Some of the key respondents identified patriarchal power relations (providing room for univocal decisions and imbalanced labor burdens) as impeding mechanization. In what follows we will broaden the investigation to include other institutional sites. Asked about how they would envision more sustainable and equitable mechanization, key informants brought up four aspects: education and training, collective action, changes in the availability and design of machines and a transformation of norms surrounding machine operation and technical jobs in general. These aspects are outlined below and summarized in Table 5.

In terms of education and training, several key informants saw an increase in farmers' knowledge and use of mechanized maize shelling over the past few years, but also emphasized the need for more demonstrations and hands-on training (especially in relation to small engine-powered shellers). A woman agricultural mechanic demanded training for women at the village level to encourage female participation. Some of the existing training events were criticized as being not sufficiently aligned with the challenges facing farmers. Such measures, in particular demonstrating how to use the machine without any further advice in respect of maize production, would not necessarily make mechanization more inclusive, as one extension officer from Babati argued. If farming practices were not improved in an overall manner, he said, women in poor households would have to continue shelling by hand to avoid costs. Changes in various steps of the maize production process would have to be implemented first to increase a household's productivity and income. Timely and better weeding, or the establishment of adequate storage facilities, were mentioned as examples. The latter would also enable farmers to sell maize at times when they fetch better market prices. Only when these improvements were accomplished would mechanized shelling become feasible for less wealthy groups, he concluded. In a similar vein, an extension officer from the same district recommended a holistic approach, namely integrating training on mechanized shelling into the broader ongoing learning activities of farmers' groups. But the sustainability of mechanization was also seen as being dependent on the concerted and long-term efforts of development actors. One respondent commented that NGOs and extensionists often cooperate in organizing mechanization training, but continuity is challenged when NGOs withdraw at the end of a project. He put this down to the extension officers' meager funds, large constituencies and in some cases their preference for involvement in activities for which allowances are paid. He saw farmers' groups that benefit from the efforts of NGOs as an alternative pathway to mechanization.

In our sample, both members of farmers' groups and extensionists considered collective machine use not only as an efficient way of offering training and ongoing support but also as a way of reducing shelling costs. Individual shelling entrepreneurs would at times set prices that exclude poorer households in need of services, a woman respondent said. Key informants agreed that for shelling the same amount of maize, entrepreneurs charge approximately one-third more than the fee charged by farmers' groups (around US\$0.45 vs 0.32 for one 100 kg bag of maize at the time of the study). However, the larger community can only benefit where farmers' groups offer services beyond their core membership. At this point, processes in the community extend into the market institutional site. Another aspect respondents discussed was the group arrangements chosen by development actors to support the acquisition and operation of machines. One respondent complained that instead of building on existing groups, such as loan associations with constitutions and long-term plans, some investors agree to *ad hoc* arrangements that turn out to be neither equitable nor sustainable due to their opportunistic character. He explained that it is the prospect of getting a tractor and the rush development actors are sometimes in that will make you 'bring your uncles and siblings.' One shelling entrepreneur said that where collective action and learning are genuine long-lasting processes, they may also constitute informal business incubators (a second interrelation between market and community sites). 'In the beginning I was not capable of doing anything on my own. I had to gather strength. What helped me

Table 4. Household decision-making on shelling (men-headed households only, $n = 196$ men and 115 women)

Who in the HH decides?	Mostly the man (%)		Mostly the woman (%)		Joint decision (%)	
	Men	Women	Men	Women	Men	Women
Respondent category						
Hiring of labor for shelling	56.6	40.0	2.6	10.4	40.8	49.6
Renting of shelling machine	56.1	37.4	3.1	10.4	40.8	52.2
Purchase of shelling machine	46.4	37.4	3.1	9.6	50.5	53.0

Table 5. Suggested changes in key institutional locations based on respondents' accounts

<p>Market</p> <ul style="list-style-type: none"> Transformation of gender-biased suitability criteria for machine operation to open up employment opportunities for women Improving market information on mechanization demand Sensitization of mechanized input suppliers and manufacturers to farmers' preferences (including gender-sensitive machine design) Promoting farmers' groups as mechanization business incubators 	<p>Household</p> <ul style="list-style-type: none"> Transformation of inequitable norms shaping labor burdens and decision-making, as well as beliefs in 'superior' male technical skills
<p>Community</p> <ul style="list-style-type: none"> Improving farmers' organizational arrangements for training and machine use (constitutions, equitable participation) to ensure the availability of low-cost shelling alternatives as compared to existing market supply 	<p>Government</p> <ul style="list-style-type: none"> Revision of school curricula to promote girls' choice of technical subjects and careers Promotion of gender-sensitive training and machine design in organizations with government mandate for agricultural mechanization (for instance SIDO, CAMARTEC)
<p>Community/Government</p> <ul style="list-style-type: none"> Embedding mechanization into comprehensive agricultural training and extension services to remove obstacles to mechanized shelling in preceding and subsequent labor steps Concerted long-term mechanization efforts by development actors 	

was the cooperation,' he said about the group which facilitated his start-up. However, not a few respondents viewed farmers' groups as being prone to conflicts over leadership, responsibilities, machine use and maintenance.

In terms of machine availability, a representative of the SIDO explained that in rural centers shelling machines are often not available for sale and if they are, they are too expensive for most small-scale farmers. He suggested the local production of simpler machines that can be sold at affordable prices. A local manufacturer, on the other hand, said that the expansion of his business is hampered by limited market information concerning the demand for shelling equipment. To align machine design and operation with farmers' preferences, respondents suggested the following: small shelling machines should have wheels, or come with a special cart to ease transportation. Engineers and operators should make efforts to minimize maize cob breakage since undamaged cobs are valuable as fuel. This would reduce the burden of searching for fuel, work which is usually performed by women. Furthermore, there is a demand for machines that are user-friendly in terms of the physical strength needed for ignition and operation. 'We need machines that can be easily started and operated. Many women do not want to use a lot of energy to operate a machine, while at home they are already doing other hard work. Even men, when they grow older, they need machines that are easy to use,' said a woman agricultural engineer working for CAMARTEC. Another engineer identified the height of hoppers as problematic and proposed to re-design (if possible lower)

them to reduce the labor of lifting maize when loading the machines.

Apart from features of machine design, several respondents spoke about norms conveyed at home or at school that discourage women from engaging in mechanization. One engineer explained: 'Girls and women are taught that they are not in charge of machines. As a result, we not only have to empower them financially or in terms of access, we also have to build their self-confidence. There is this fear that makes them run away from the machine. It causes women not to benefit from mechanization and not to receive relief.' Another key informant emphasized the importance of women's presence in technical occupations to champion broader change and commented: 'Very often trouble starts at school. School is the source of these problems. This is the place where future engineers can be cooked.' She demanded that school children should be enlightened about various job profiles and requirements, in order to promote girls' conscious choice of technical subjects and careers. Thus, equitable agricultural mechanization was linked to changes in primary and secondary socialization.

Discussion

Based on Kabeer's four key institutional sites, Table 5 summarizes the changes respondents identified as necessary for moving toward more equitable and sustainable mechanization. For instance, male-dominated household decision-making has far-reaching implications for labor roles and burdens and the

adoption of mechanization. Gender-transformative work could address these imbalances and should be integrated into comprehensive agricultural training at the household, community and government levels (Farnworth and Colverson, 2015). At the same time, the transformation of inequitable gender relations and of beliefs in 'superior' male technical skills would support shifts in labor patterns at the market level toward more engagement of women in technical jobs. This should go hand in hand with efforts to revise school curricula and to create equitable participation in farmers' groups. Changes in gender norms that hamper equitable mechanization are more likely to happen and be sustained where transformative efforts are launched at multiple scales and show synergies. We concur with Sims *et al.* (2016) that a critical analysis of local norms and values is vital to ensuring women's access to mechanization.

The inclusiveness of mechanization will also depend on the variety of shelling services available, especially in terms of costs. Farmers' groups and shelling entrepreneurs are not just alternative providers in this respect. The former could be more strongly promoted as business incubators for the latter (see FAO and AfDB, 2019 for such efforts in Cote d'Ivoire). Development actors coaching entrepreneurs to start-up mechanization businesses should encourage women's participation. Where loans or capital are provided, 'more flexible finance schemes should be established especially for women and youth who want to engage in mechanization services' (FAO and ACT, 2017, p. 20). A better exchange between entrepreneurs, farmers, local manufacturers and government organizations could support the tailoring of machine design to users' preferences (including gender considerations). This underlines the demand made by Sims and Kienzle (2017, p. 11): 'Improving women's access to farm power through the provision of suitably designed equipment needs to be addressed by the actors in the farm power provision supply chains' (see also Kormawa *et al.*, 2018). In-depth studies of gendered preferences are necessary to develop suitable shelling machine designs.

All in all, mechanization needs to be embedded into larger processes of change to make it equitable. This requires concerted efforts by development actors in all key institutional locations, as well as continuous concomitant analysis of 'who the beneficiaries of mechanization are, who can afford it, and who will be disadvantaged' (Sims and Kienzle, 2006, p. 56). Such an analysis will help to better align comprehensive agricultural training to the demands of social groups that mechanization potentially leaves behind. In our sample, these were low-income, elderly and less educated farmers. At the household level, attention should be paid to the sequence of labor steps and to how each step's degree of drudgery or mechanization relates to the overall process and its outcomes (productivity, income, labor). This includes the question of how workloads are eased, shifted or shared, and to whose benefit. As our data show, shelling machines reduce the toil of manual shelling which is often assigned to women. But women's contribution to decision-making on mechanization is limited and other burdensome jobs remain (such as weeding and harvesting). If gendered labor patterns are not investigated in an overall manner and transformed into fair arrangements (including domestic work and child care), the mechanization of selected labor steps may actually increase female burdens. Cases in point are where higher productivity results in higher workloads at other points in the production and post-harvest cycle (Kansanga *et al.*, 2019), or where women are directed to dedicate their freed-up time to additional work (Kiyimba, 2009).

Referring back to the other investigations presented in the section Conceptual Framework, we conclude as follows: for the example of maize shelling in Tanzania, we confirm deep-seated patriarchal norms that govern the distribution of resources, responsibilities and power, and impede women's effective involvement in mechanization in all institutional sites. In contrast to other studies, however, we have placed more emphasis on providing room for respondents to envision how equitable and sustainable mechanization could be achieved. This emphasis, together with the selected conceptual framework, is in line with recent calls for stakeholder participation, holistic approaches and gender analysis in mechanization studies (see the section Introduction). In articulating their demands, our respondents outlined entry points for support in respect of more equitable mechanization that have not yet received sufficient attention. These include re-designing farmers' collective mechanization groups as gender- and youth-sensitive business incubators, or attracting more women into agricultural or mechanical engineering courses to promote gender-balanced employment and the transformation of male-biased norms. Broad stakeholder participation, not only in the description and critical analysis of the current situation but also in the development of future scenarios, should be strongly integrated into future research on mechanization.

Conclusion

Tanzania's Agricultural Mechanization Strategy (URT, 2006) recognized rural women's excessive workloads, their disadvantaged access to education (including extension services and business skills) and their lack of capital to engage in mechanized activities on the household or market levels. It promised to mainstream gender in agricultural mechanization interventions through the following measures in a 5-year plan: promotion and demonstration of easily accessible and 'gender-friendly' implements, recommendations to manufacturers on gender-sensitive farm machinery and increasing female participation in training on mechanization. Almost 15 years after the publication of the strategy, the above measures are still needed, as key informants in our study pointed out. This shows not only that gender transformation is a long-term process, but also that efforts need to be increased at multiple scales to make mechanization equitable and sustainable.

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