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RESEARCH ARTICLE

The importance of gender roles and relations in rural agricultural technology development: a case study on solar fruit drying in Mozambique

Pia Piroschka Otte[a], Lucas Daniel Tivana[b], Randi Phinney[c], Ricardo Bernardo[d] and Henrik Davidsson[d]

[a]Ruralis-Institute for Rural and Regional Research, University Centre Dragvoll, Trondheim, Norway; [b]Agrarian Engineering Section, Rural Engineering Department Faculty of Agronomy and Forest Engineering, Eduardo Mondlane University, Maputo, Mozambique; [c]Department of Food Technology, Engineering and Nutrition, Lund University, Lund, Sweden; [d]Energy and Building Design Division, Lund University, Lund, Sweden

ABSTRACT

Many agricultural technology interventions that aim to improve farmers' livelihoods focus on households as the unit of analysis and ignore gender roles that entail different benefits and costs for different household members. Agricultural projects have shown limited success where gender roles and relations were ignored and thus more gender sensitive research is needed in agricultural technology development to ensure social acceptance. In this study, we address this need by investigating the importance of gender roles and relations in the case of solar fruit drying in Mozambique. We apply a variety of gender sensitive participatory methods that enable farmers to actively take part in the technology development process. First results indicate that the costs and benefits of solar fruit drying are not shared equally between genders. Women have much less time available for using the solar fruit dryer. The data also indicate that certain steps in the solar fruit drying process are clearly gender divided. We finally discuss potential mechanisms that can be applied in agricultural technology projects that can create awareness of the risk to reproduce traditional gender roles and unequal relations in the development process of new agricultural technologies.

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Gender roles; gender relations; technology; development; solar fruit drying; Mozambique

Introduction

The adoption of new agricultural technologies among farmers is often very limited and the factors explaining this limited uptake are often poorly understood (Bandiera & Rasul, 2006). Traditionally, agricultural technology development followed a universal linear approach of transfer where technologies were first tested with experiments, and then transferred via extension workers to farmers. This one-way process did not allow

CONTACT Pia Piroschka Otte pia.otte@ruralis.no Ruralis-Institute for Rural and Regional Research, University Centre Dragvoll, N-7491 Trondheim, Norway

for any information to flow back from the farmers to the researchers (Grabowski, Kerr, Donovan, & Mouzinho, 2015). It did not consider farmers' practical knowledge that is crucial for the development, design and implementation processes of agricultural innovations. Thus, many of these technologies were not taken up by farmers and it was realized that successful agricultural technology development and implementation requires a two-way communication process that combines 'farmers' detailed knowledge about their problems with scientific problem-solving skills from different academic disciplines' (Grabowski et al., 2015, p. 11).

Over the years, a variety of participatory methods have been developed as a tool to enable farmers to be involved in agricultural technology development and transfer. However, participation is not always as effectively implemented as it is advocated. According to Grabowski et al. (2015, p. 12), 'the de facto mode of operation continues to be technology transfer from researcher to farmer, with limited use of farmer participation in the technology development process'. Furthermore, there are different levels of participation and participation per se does not ensure that existing gender roles and relations are considered that might be crucial for the long-term adoption of agricultural technologies in a particular area.

Many agricultural technology interventions that aim to improve farmers' livelihoods focus on households as the unit of analysis; however, the assets and skills are transferred to individuals who are part of the household but not the household as such (Johnson et al., 2015, p. 146). This might lead to that the project's intended benefits are not equally distributed among the household's members (ibid). Farmer families consist of different individuals and their relationships and roles are shaped by existing gender roles, which are deeply anchored in traditional, cultural and religious beliefs (Garcia & Wanner, 2017). Thus, it is very important that participatory interventions take gender roles and relations into consideration to ensure a higher degree of success of the technologies (Johnson et al., 2015; Njuki, Kaaria, Chamunorwa, & Chiuri, 2011). New agricultural technologies can influence gender relations in two ways: by changing underlying gender relations or by reinforcing existing gender and power imbalances (Huyer, 2016, p. 112) by, for example, re-emphasizing an unequal gender division of labour (Johnson et al., 2015). Previous studies have shown that female farmers tend to adopt new technologies and agricultural practices slower than male farmers (Doss & Morris, 2001, p. 27) often because new technologies lead to an additional workload that often seems to fall on women (Jost et al., 2016). Thus, it is crucial that agricultural technology development projects include a gender perspective early on in the project implementation (Bellon, 2001; Johnson et al., 2015; Murray, Gebremedhin, Brychkova, & Spillane, 2016) to assess the impact and ensure that the benefits of a new technology are more equally divided.

Previous literature on gender relations in agriculture in Mozambique mainly addresses the differences between male- and female-headed households without investigating gender relations between men and women within households (De Brauw, 2015). This study contributes to this gap by investigating the importance of gender roles and relations in agricultural technology development in the case of solar fruit drying in Mozambique.

A gender perspective to agricultural technology development

Women in the Global South have very unequal access to agricultural land and resources, even though they are the main cultivators (Kerr, 2017). In addition, agricultural practices are deeply characterized by traditional gender roles that build up on existing patriarchal social and cultural norms that limit women's empowerment. These need to be challenged by gender sensitive policies that can open up gendered division of labour and provide women with equal opportunities as men (Garcia & Wanner, 2017).

The focus of this study is on exploring traditional gender roles in the case of a solar fruit drying project that consequently influences gender relations. Gender relations concern gender roles since they address the uneven roles, responsibilities, access to resources and decision making patterns between men and women at different scales in a given society (Kerr, 2017, p. 338). This addresses fundamental questions of inequality and thus power relations that 'are produced through situated and embodied practices that form patterns and produce material and social effects' (Ahlborg, 2017, p. 128).

The development of new agricultural technologies, such as solar fruit dryers, can influence gender roles and consequently gender relations in two ways. In the negative case, they can lead to a reproduction of traditional gender roles and unequal gender relations. However, these technologies can also lead to an empowerment of women and thus change gender roles and relations towards more egalitarian rural societies.

Feminist perspectives to technology and development argue that gender is not the only socially constructed concept that becomes relevant for agricultural technologies. It presents one category that interacts with multiple social concepts (such as, for example, age, social class and ethnicity) (Eriksson, 2017; Gonda, 2016; Nightingale, 2011; Valentine, 2007). Kerr (2017, p. 338) illustrates several examples from the Global South that show how age and class intersect with gender roles to influence agricultural systems. Even though the focus in our study is strongly on gender, we cannot look at gender alone but need to acknowledge how gender is interwoven with other social factors. Women in our case study are not only women per se; they are also mothers, housewives, farmers and members of agricultural associations. In addition, several scholars have argued for a spatial focus on intersectionality that takes the identity of spaces – prescribed by dominant intersected identities – into account (Nightingale, 2011; Valentine, 2007). Social identities are shaped in their particular context and need to be taken into consideration for technology development and training.

Background Mozambique: gender, agriculture and solar fruit drying

Gender equality and women's empowerment have been for a long time on Mozambique's political agenda. Since Mozambique's independence in 1975, women's political representation and participation has steadily increased, with 36 percent of the seats in parliament taken by women in 2010 (Tvedten, Paulo, & Montserrat, 2008). Despite this political engagement of women, structural constraints and a strong patriarchal culture limit women in their economic and social actions (ibid). The latest data from 2014 shows that Mozambique ranked 135 out of 155 countries on the GII

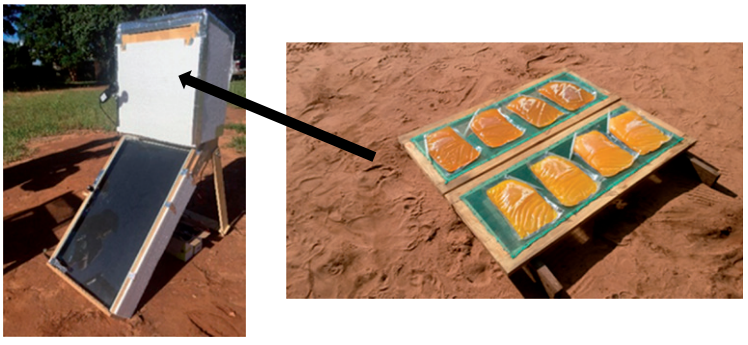

Figure 1. Solar collector and prototype membrane pouches. Source: Authors.

(Gender Inequality Index) (UNDP, 2015). There are also huge differences between urban and rural areas and the North and South in Mozambique (Tvedten, 2011).

Agriculture is the main source of income in Mozambique, providing an income for more than 70 percent of its population and accounting for 31.8 percent of Mozambique's gross domestic product (GDP) (Cammaer, 2016, p. 6). Despite the importance of the agricultural sector for Mozambique's economy, many people still go hungry. The country shows high rates of chronic undernutrition, with the highest ones for children under 5 years in the Northern provinces (47–55 percent) (UNICEF, 2014). One reason for these high numbers is that Mozambican smallholder farmers do not produce enough food all year round. Many farmers only produce enough food to feed their families for less than 8 months (Cunguara & Hanlon, 2012, p. 630). This is mainly due to low production levels. It is estimated that only 12 percent of arable land is cultivated (Grabowski et al., 2015, p. 18). Furthermore, according to the FAO (2016), Mozambique's diet has not diversified because of low diversity of food production, difficult access to nutritious food and little knowledge concerning nutrition among the population. Women are often in charge of post-harvest food storage (Hyder et al., 2005). However, the options for storage are very limited which leads to post-harvest losses, particularly of citrus fruits. Citrus fruits ripen in a very short time and what cannot be eaten or sufficiently stored spoils rapidly. Post-harvest fruit losses are estimated to be 25–40 percent in Mozambique, where much of the fruit remains unharvested because of a short ripening season (USDA, 2011). Inharrime district, located in Inhambane province, with an estimated citrus production of 25,000 tons per year (Governo do distrito de Inharrime, 2012), has a high potential for new agricultural technologies that can preserve these fruits on time and thus reduce post-harvest and unharvested losses. Conventional preservation technologies – such as canning and aseptic processing – are often not economical for smallholder farmers. In addition, they require large investments, energy and transport infrastructure that is very limited in rural areas in Mozambique. Thus, a simple and affordable technology is needed that can preserve fruits close to where they are grown. Mozambique has a high solar energy potential that could be harnessed for solar drying. The annual solar radiation on an horizontal surface in Maputo is approximately 1900 kWh/m^2/year[1].

The main aim of the solar fruit drying project is to explore this potential by combining solar collector technologies with newly developed membrane pouches for drying

and thus preserving citrus fruits that would otherwise spoil. The membrane pouch is a sealed bag made of a foodgrade breathable membrane that can concentrate fruit juices or purées by using solar irradiation and ambient air (Phinney, Rayner, Sjöholm, Tivana, & Dejmek, 2015). A prototype version of the membrane pouches and an example of a solar drying collector are illustrated in Figure 1.

Successfully engineered solar dryers combined with membrane bags have the potential to increase drying temperatures and productivity, decrease drying time, improve vitamin retention, and protect the final product from external contamination such as dust and insects (Phinney, 2017). Thus, they have a high potential to improve overall food safety. A variety of dried fruit products can be produced such as fruit juice concentrates, jam and/or dried fruit bars or candy. The selling of these products at the local market could provide an additional income for the smallholder farmers involved in this work.

Methods and data collection

In the solar food project, we work with two farmer associations that mainly grow cassava, groundnut and cowpeas in Inharrime. We decided to work with associations over individual households since previous research from Mozambique has shown that members of agricultural associations are more likely to adopt new agricultural technologies (Uaiene, Arndt, & Masters, 2009). One important explanation for higher levels of adoption is that group membership can increase farmers' exposure to new information about new technologies so that farmers who are a part of agricultural associations are more likely to adopt new technologies (Aura, 2016). Furthermore, the farmers are used to sharing agricultural equipment at the associations, where the solar fruit dryer could be an additional technology to include.

The first association is dedicated to cassava root processing. They have several cassava processing machines. Nearby farmers join the association because it helps them to sell their products and they avoid competing with one another. During the operation period of cassava processing (May–November), the members divide the profit from cassava sales. The cassava is mainly sold in the form of rale[2]. There is no direct membership fee to join the association but new members are not eligible to the same earnings as old members from the cassava sales. The processing facilities can be used by members and non-members to process their individual cassava roots. However, non-members are required to leave about 30–50 percent of the processed product with the association. A similar set up could be imagined for the solar fruit drying technology, where the solar dried products would be shared among the members.

Both associations embody strong patriarchal governance structures. They are managed by a president, vice president, elder counselor and a secretary/treasurer, whereby all these posts are taken by men, partly due to their higher educational status. Many women are illiterate and have not completed primary school. They mainly speak the local language (Chopi) whereas most of the men speak Portuguese as well. The first association has 28 permanent members, where women are in the majority (9 men and 19 women).

The second association is a recently founded farm field school dedicated to cowpea production. There are clearly divided gender roles in the production process. Women

are responsible for the harvesting and processing of cowpeas, whereas men prepare the soil. The association has 18 permanent members of which 3 are men and 15 women. They sell and keep some of the cowpeas, which are divided among the members. Members of both associations decided freely to participate in the research and were not priory selected. The number of farmers in the groups varied from day to day, but we had in total per group between 8 and 17 farmers per day. Both associations have a close connection from before, which made it possible for us to conduct participatory exercises at one of the two associations.

Our research is of a qualitative nature, which does not allow for a wider generalization of the findings due to the small sample size. However, the study provides insights into gender relevant concerns for agricultural technology development and implementation that can serve as valuable lessons for development practitioners, but where the specific contexts will differ. It also provides new thought-provoking stimuli for methodological and theoretical concerns on gender and technology. We conducted a variety of participatory methods between the 2nd and the 25th of April 2016 as part of the first empirical data collection of this three year project. We undertook seven different participatory exercises, which investigated crucial socio-cultural dimensions of agricultural technology development and adoption. An overview of the exercises is presented in Table 1.

For the discussion in this paper, we will focus on exercise ID 1, 4 and 5 (highlighted with bold letters in the table) that shed light on the gendered character of the technology itself and that could influence the development and adoption process for solar fruit drying. These include a daily schedule exercise and an exercise investigating farmers' perceptions on the degree of difficulty and gender division of labour when using

Table 1. Overview of the conducted participatory methods (emphasized exercises are highlighted with bold letters).

Date	Exercise ID	Exercise	Purpose	Level
07.04	**1**	**Daily schedule**	To get an overview of daily activities and possible available time for solar fruit drying	Group[a]
08.04	2	SWOT analysis	To identify internal and external factors that are (un)favourable for solar fruit drying	Group
11.04 13.04	3	Transect walks	To understand the lives and livelihoods of farmers for solar fruit drying	Individually
12.04	**4**	**Difficulty assessment of solar fruit drying process**	Ranking and scoring to find out which steps in the solar fruit drying process are considered to be most difficult by the farmers	Individually
12.04	**5**	**Assessment of division of labour in the solar fruit drying process**	To identify shared responsibilities in the solar fruit drying process	Individually
14.04	6	Technology requirements	Ranking and scoring of different technology requirements by the farmers	Group
11.04–19.04	7	Photo voice	To give the farmers a voice concerning agricultural activities	Individually

[a]Participatory group exercises were normally held between 9:30 and 14:30 since this presented the most convenient time for the participants (particularly the women) to take part in the work. Later afternoon hours would have been difficult because the women had to return to their homes, to prepare evening meals and many of them had to walk long distances to their homes (between 0.7 and 5 km). The groups were divided into women and men.

the solar fruit dryer. All exercises were undertaken at one of the two farming associations where members of both associations gathered.

Daily schedule

Daily schedule is a very common exercise for investigating women's activities and gender differences in the workload (Narayanasamy, 2009, p. 195). For the daily schedule exercise, we divided men and women into two groups to identify the daily activities and amount of time they use for each task. In total, 8 women and 6 men were present for the exercise that day. The overall aim of this exercise was to find out whether men and women would have time to use the solar fruit dryer, and at which time during the day if they did have time. Since we were not sure if our informants could estimate the exact hours they use for each activity, we chose the daily schedule exercise based on a relative estimation of time. Adapted from Narayanasamy (2009), we used symbols to illustrate different activities and we used cowpeas to indicate the proportion of time. The more cowpeas an informant would assign to an activity, the more time demanding the activity would be. We divided the day into 12 hours (6 am to 6 pm, which represents the daylight hours in Mozambique, since most of the activities are undertaken during this time). The farmers received 12 cowpeas to distribute for the different tasks.

Difficulty assessment and gender division of labour

The second exercise addressed the solar fruit drying process itself. The aim of this exercise was firstly to assess the degree of difficulty of using a solar fruit dryer perceived by the farmers and explore a potential gender division of labour for different tasks in the solar fruit drying process. We divided the solar drying process into eight different steps, which are illustrated in Figure 2. We presented these eight steps to the farmers in English and Portuguese on post it notes on a flip chart paper. In addition, they were explained in Chopi (the local language).

The participants received 40 cowpeas, which they could use for ranking. In total 17 farmers participated in the exercise (7 men and 10 women). The group was divided into men and women and each participant had to fill out the sheet individually so that they could not influence each other. In the second part of the exercise, we gave

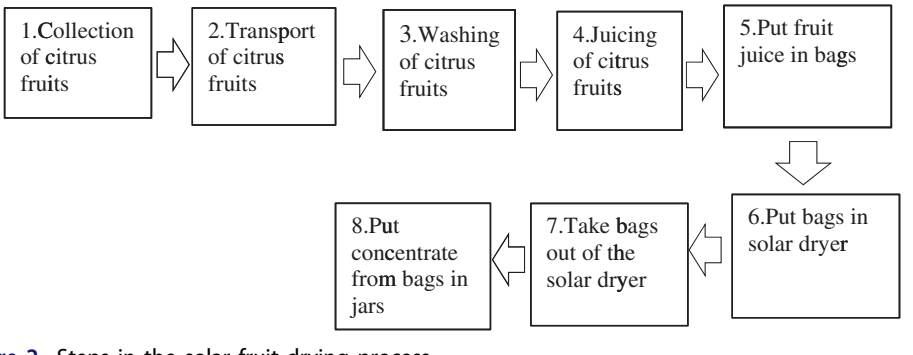

Figure 2. Steps in the solar fruit drying process.

Figure 3. Difficulty assessment of solar fruit drying (men and women). Source: Authors.

each participant three post-it notes illustrating men, women and children. We asked the participants to place each figure in the order they thought the different groups would be responsible for a particular step below each of the eight steps on the flip chart. This exercise assisted in identifying pre-ascribed gender roles in the solar fruit drying process. Figure 3 illustrates the difficulty assessment undertaken with both groups.

Results

Gender, labour and time constraints

Previous research has shown that women tend to work more hours than men (Doss & Morris, 2001; Hyder et al., 2005; Murray et al., 2016). Rural women in Mozambique have almost twice as many hours of work per day compared to men (Sida, 2007, p. 30). This implies that women are much more restricted in their activities than men and this can influence women's engagement in activities. It explains their often lower levels of education compared to men and might also limit their involvement in solar fruit drying. Our daily schedule exercise confirms this. Our original idea of dividing the day into 12 hours (of daylight) was not appropriate. In the beginning of the exercise, the women told us that during the intense farming season, their working day is longer than 12 hours. To avoid excess exposure to the sun, women get up at 3 a.m. in the early, colder morning hours to ensure they have enough time throughout the day to complete not only the work on their individual farms and domestic tasks (e.g., cleaning

and cooking), but also the work of the association. As association members, the women contribute to the agricultural work at the associations as well. In both associations, the processing work is mainly done by women.

After working for 2 to 3 hours in their own field in the early morning (from ca. 6 am when the sun is up), they join other members to work for one hour in the field that belongs to the association. In the harvest season, they work in total 9 hours on the farm, of which approximately 3 hours are on their own farm where they are harvesting, drying, and gathering, and 6 hours are with the association where they are harvesting, drying and processing. During harvest season, the association does not only work with its own cassava processing, but the members also process cassava that is brought to the association by other people. In addition to farm work, the women have to do the housework as well, which leads in total to a 15 hour working day during the harvest season. During this time, they have problems to undertake all their domestic duties so they tend to transfer some of the household tasks to their children. The women expressed a generally high interest in fruit drying but lacked considerable time during normal working days to do this. They also mentioned that they do not want to use the time when they normally work with cassava production since their livelihood depends on this work and solar fruit drying presents a new risky agricultural practice with an uncertain outcome. In addition, the process would be quite time intensive since it is a new agricultural practice that requires a new routine. Therefore, they suggest initiating solar drying on the weekends when they do not have to work at the association but only at home on their own farms.

In comparison to the women, men did not express concerns regarding lack of time for the solar fruit drying activity. Most of the conversation with the group of men became channelled towards matters of tools, machines and drying processes. They showed a high technical interest. They expressed the importance of being empowered to be able to perform the drying on their own without the need of external support. Our results from the daily schedule exercise confirm what previous studies from Mozambique and other sub-Saharan African countries have shown: that men, in general, have much more free time than women to get involved in new agricultural technologies (Hyder et al., 2005; Saito 1994 in Doss, 1999, p. 3).

Table 2. Women ranking difficulty of tasks.

Case ID	Collection	Transport	Washing	Juicing	Put in bags	Put in solar dryer	Take out bags	Put in jars	Max Score[a]
1	3	8	2	1	1	4	1	1	8
2	6	8	3	2	3	2	1	1	8
3	8	5	6	3	7	7	5	5	8
4	3	5	3	2	3	2	2	5	5
5	4	5	3	4	2	1	2	8	8
6	3	8	2	1	4	2	1	3	8
7	8	4	3	1	2	5	4	7	8
8	4	6	3	2	5	4	2	2	6
9	5	8	5	3	2	4	3	2	8
10	3	6	3	2	5	4	3	6	6
Average	4.7	6.3	3.3	2.1	3.4	3.7	2.4	4.0	

[a]The maximum score indicated the highest perceived degree of difficulty.

Table 3. Men ranking difficulty of tasks.

Case ID	Collection	Transport	Washing	Juicing	Put in bags	Put in solar dryer	Take out bags	Put in jars	Max score[a]
1	3	5	2	1	2	3	1	1	5
2	1	8	2	1	3	4	2	1	8
3	1	9	1	1	1	2	1	1	9
4	4	8	4	1	2	1	2	1	8
5	5	8	5	1	7	8	3	2	8
6	1	5	1	1	3	4	6	1	6
7	2	8	3	1	2	1	1	3	8
Average	2.4	7.3	2.6	1	2.9	3.3	2.3	1.4	

[a]The maximum score indicated the highest perceived degree of difficulty.

Assessment of the perceived difficulty level of solar fruit drying

The quantified results of the difficulty assessment for the two groups are presented in Table 2 and Table 3[3]. The tables show that women and men rank the difficulty of the steps differently. However, there are also clearly some commonalities. Seven out of ten women and six out of seven men regard the transport of citrus fruits from the individual farms to the association as the most difficult task. Citrus fruits (e.g., tangerines) are very difficult to transport since they are very soft and break easily. The women mentioned that the distance is too long. Since they do not have motorized transport, they are highly dependent on human labour for the transport of citrus fruits. Transport is considered as one of the major challenges in rural areas in sub-Saharan Africa (Murray et al., 2016). Walking presents the main transportation mode for men and women. Women are particularly limited in their mobility. They often have limited access to markets and in a patriarchal society, men often do not want their women to travel far because they associate this with promiscuity, which limits women from selling food at more distant markets (Porter, 2011). For the women farmers in Inharrime, the access to the market is less of a problem since they could sell the solar dried products through street vendors along the main road that is not far from the association where the products would be produced. Many smallholder farmers have built their houses close to the road to sell their products to bypassing travellers. The solar dried products could present an additional item for sale. However, the distances between the individual farms, where the fruits have to be picked, and the association are more of a concern for the women's group.

Besides transport, two men also mentioned that they assume that (1) putting the juice in the bags and then (2) putting the bags inside the solar dryer and (3) taking them out again would be the most challenging tasks. This may have been due to two reasons. First of all, it was not clear what the technology for completing these tasks would involve. We intentionally did not mention the size of the bags or how the equipment would be operated prior to the needs assessment because we did not want to create biases or pre-defined mental images of what to expect with the technology. Showing the first prototypes to the farmers at this early stage would most probably have led to a general high interest in the technology without ensuring whether this technology was really adapted to the farmers' requirements.

Secondly, the three steps that the men consider difficult are new for the farmers who are used to conventional solar drying processes of cassava and beans, which are dried on an open surface without using bags to produce concentrates. It could also be

that these men have had unsuccessful experiences with solar dryers in the past. Some members mentioned that a solar dryer had been given to them in the past to dry cassava but due to a poor design, it did not dry the cassava fast enough and instead their valuable crops were spoiled. Negative memories such as these could have been the reasons for the anticipated challenges expressed by these men for these steps of the process.

Gender division of labour

The answers related to the gender division of labour show very interesting results. When comparing the answers given by women and men in Figures 4 and 5 we can see that women much more frequently involve children in the solar drying process

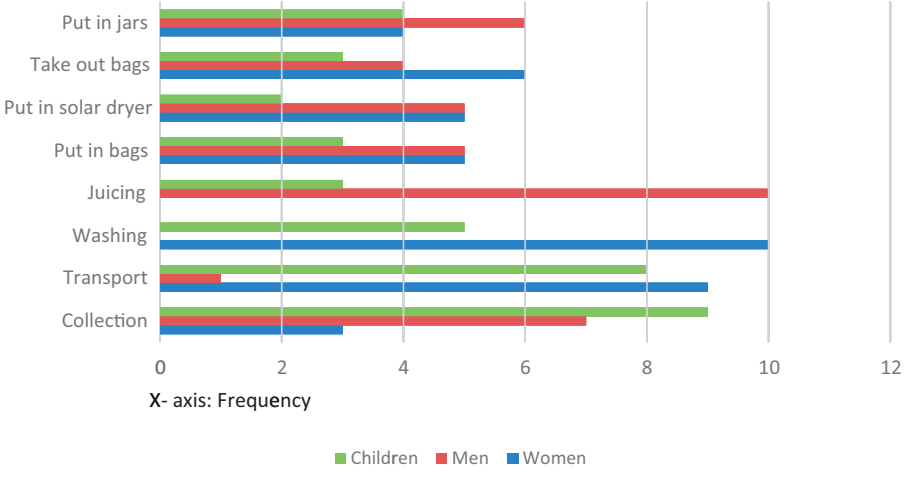

Figure 4. Gender division of labour (Results women). Source: Authors.

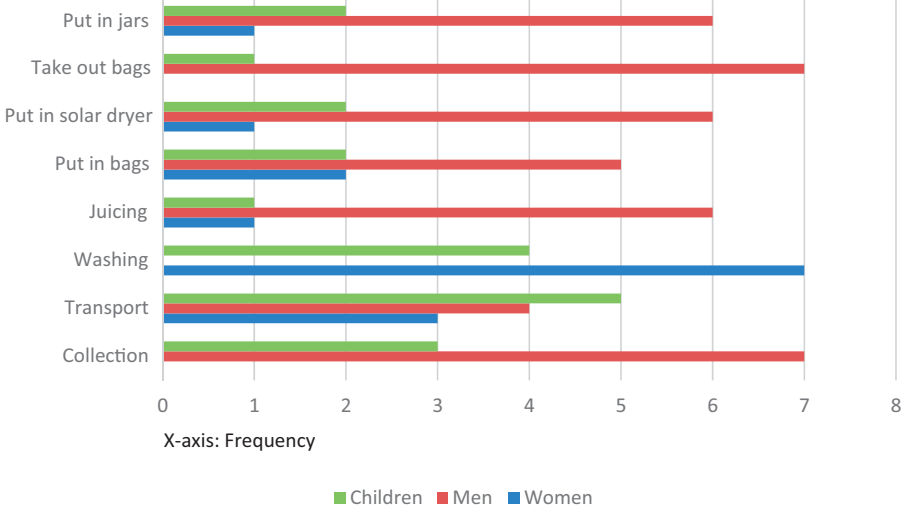

Figure 5. Gender division of labour (Results men). Source: Authors.

than men[4]. Children are particularly involved in the first, second and third tasks that include the collection, transport and washing of citrus fruits. They are much less expected to be involved in the work with the solar dryer itself. One explanation for why women involve children more frequently is based on their traditional involvement of children in domestic and agricultural tasks, especially girls. Children often already collect firewood and water, so the collection and transport of tangerines could just present an additional item here to collect. Research from Malawi has shown that the tasks among children are also highly gendered. Girls assist in domestic tasks while boys help with construction tasks (Murray et al., 2016, p. 127). Domestic work can prevent children, especially girls, from attending school. Previous research from Ghana and Malawi showed that girls had to undertake a variety of household tasks before school, which often meant that they arrived tired at school or dropped out of school completely (Porter, 2011). It is important to investigate further in the project whether the use of a solar dryer could actually lead to an additional workload for children, particularly girls, and prevent them from going to school.

Overall, when comparing the two figures we can see that the men ascribe much more tasks to themselves than the women do. This might refer to underlying traditional gender roles that view men as primarily responsible for farming cash crops (Murray et al., 2016). Solar dried products were presented to the farmers as a new income generating activity and could thus imply the status of a cash crop that is traditionally ascribed to men. In this case, solar dryers would clearly limit the involvement of women and lead to the reproduction of traditional unequal gender roles and relations.

Concerning the gender division of the different tasks in the solar fruit drying process, there are two main tasks that are strongly gender divided. 'Washing' is by both groups clearly stated as a task undertaken by women, with 10 out of 10 women saying that they would do the washing of the tangerines, and 7 out of 7 men stating that women would do the washing. 'Juicing' is clearly perceived as a man's task. 10 out of 10 women stated that men would be in charge of this and 6 out of 7 men stated that men would be in charge of it. This might be because we told both the groups that the juicing would be undertaken with a manual machine since the farmers stated a strong dislike for peeling citrus fruits. Underlying cultural attitudes concerning technology and technology use often discriminate women and consign technologies to men's sphere of influence in Mozambique (Sida, 2007, p. 59). This is not limited to the Mozambican case but has been also observed in other cross-cultural contexts in sub-Saharan Africa, particularly in terms of men's hegemonic role of handling new technologies in terms of electrical appliances in Zanzibar (Winther, 2005) and solar box cookers in Zimbabwe (Rodgers, 1994). The data indicates that this becomes very relevant in the context of solar fruit drying.

Discussion

The results from the participatory exercises show that solar fruit drying as an original intended 'win-win technology' – with its potential to improve farmers' livelihoods and reduce food waste – can reinforce existing unequal gender roles and relations that prevail in the rural Mozambican society in Inharrime district.

However, in this section we discuss potential mechanisms and tools that can be applied in agricultural development projects to become more aware of the risk to reproduce traditional gender roles and unequal relations with the development of new agricultural technologies, such as solar fruit dryers.

Implications for development practitioners and policy makers

The results from the solar drying project show that gender roles have to find early consideration in technology development projects long before implementation. The exercise investigating the gendered division of labour showed that some of the steps in the solar fruit drying process are already common practice for the farmers, which makes it easier for the farmers to apply them (since they do not require specific training), but which also means that these steps might suffer from prescribed gender division. Results from the women's group indicate that tasks that were new to the farmers – particularly related to the handling of the bags and the solar dryer – do not show any predefined gender division. They can present a starting point for the development practitioners for a gender sensitive training.

However, a gender sensitive technology development and training is only possible through an enabling environment that would challenge existing social and cultural norms that determine unequal gender roles and relations. This requires macro-level targeted strategies addressed to the rural population that foresee an increased participation of women in agricultural technology development. This could be done through (1) increased programs on technology training and implementation for women, and (2) improved micro-credit schemes and loans exclusively for women to purchase new agricultural technologies (Negin, Remans, Karuti, & Fanzo, 2009). Furthermore, women empowerment initiatives need to be included in the beginning of technology development projects so that new technologies do not disadvantage women and lead to an extended work day or prevent girls from attending school. Tools, such as the daily schedule exercise, assist in identifying time slots for technology training. We can see that age becomes a relevant social concept that intersects with gender since young girls are supposed to assist in the solar fruit drying process, which will prevent them from gaining higher educational levels than their mothers. Interestingly, it is particularly the women's group that wants to include the young girls in the process, who thus reproduce these traditional gender roles, which makes it important to include the mothers in gender sensitive technology development.

In order to keep girls in school and avoid an additional work load, new agricultural practices, such as solar fruit drying, could be included as part of Mozambique's local curriculum that was originally designed to educate pupils on local context relevant practical knowledge for improving their quality of life and that of their community (Dhorsan & Chachuaio, 2008).

Already at this early stage, school classes should engage in a gender sensitive technology training where boys and girls can equally interact. This would address gender issues at a very early stage and could help to slowly change social and cultural norms towards a more gender equal society. This approach could empower young women and positively intersect with other social categories, such as educational level and social status, and ultimately create new subjectivities for these young women. It could

also help to increase parents' motivation to keep their children in school since they see a more practical value of the education being taught.

In the same way, development practitioners can include gender sensitive activities in the development and implementation process of new technologies such as solar dryers. There has been a strong focus on 'women only groups' in technology development but it is crucial to involve men as well to avoid negative drawbacks such as feelings of displacement that can lead to domestic violence (Ahmed, 2008; Garcia & Wanner, 2017) and increased gender segregation (Humphries, & Classen, 2012). Furthermore, a change in the spouse's attitudes and social practices has proven to be necessary for women to be empowered (Ahmed, 2008; Humphries & Classen, 2012). Thus, mechanisms and policies that enable joint technology ownership and collaboration between men and women are needed. One idea could be to develop innovative user guidelines for the farmers that demand a shared, interactive use of new agricultural technologies between men and women. Only by creating an enabling environment at different stages in life (school and adulthood) for both women and men, we can aspire towards a holistic gender sensitive technology development and implementation.

The role of space in gender and technology development

Valentine (2007, p. 19) argues for an advancement of the theorization of intersectionality by adding the significance of the identity of particular spaces that are 'produced and stabilized through intersectional identities of dominant groups that occupy them'. This becomes relevant in terms of gender as well, which is 'constantly (re)defined and contested in the contexts in within which it is invoked' (Nightingale, 2006, p. 171). In the case of solar fruit drying, we originally chose to work directly at one of the agricultural associations since it appeared convenient, considering the size and location, with easy access for the participants. In addition, it also presented the least intrusive place since the farmers would come there anyway to do their work and would not have to spare some of their working time for us. However, both associations embed strong patriarchal governance structures that are, on the one hand, officially anchored in leadership structures, but also become unofficially reinforced through social practices. During the data collection, we experienced several social practices that served to keep women subordinate to men. Men and women normally do not sit together but are divided into two groups, where the men sit on chairs and the women have to sit on straw mattresses on the floor to look up to the men when they interact. In addition, the women prepare lunch during the exercises, which is served first to the male elders, then the researchers, then the remaining group of men before the women can eat as well. 'Power operates in and through particular spaces to systematically reproduce particular inequalities' (Valentine, 2007, p. 19). In our case, this particular space is the agricultural association where unequal gender roles are reproduced through the way the women interact with the researchers by sitting on straw mattresses and preparing lunch in turns between the exercises. Power is 'relational, contingent, situated and produced through interactions between human actors as well as with non-human elements' (Ahlborg, 2017, p. 139). Socio-technical systems can cause de/stabilization of power (ibid). Solar fruit drying presents a new practice that can open up for new

interactions between men and women that are not based on predefined gender role descriptions. Space is a non-human element that establishes the scene for these new practices and can play a key role in re-negotiating gender power relations through the introduction of new technologies that capture new practices (solar fruit drying) and by opening up new markets (in our case the sale of solar dried fruit products) (Nightingale, 2006).

Thus, we argue for a stronger awareness of the identity of spaces in which technology development projects take place, and of how these can reinforce traditional gender roles and relations that then need to be overcome to ensure that the technology will have equal benefits for men and women and will not reproduce gender inequality. We argue for a thorough process when considering the place for joint technology development and experimentation with farmers and the aspiration towards identifying more neutral spaces that are socially and culturally blank, and where identity and power relations still have to be negotiated.

Conclusions

This article investigated the relevancy of considering gender roles and relations in early agricultural technology development in the case of solar fruit drying in Mozambique. Mozambique is a country characterized by high levels of gender inequality, particularly in rural areas and the agricultural sector. Thus, the implementation of new technologies does not necessarily embed the same costs and benefits for men and women. For the case of solar fruit drying, first results indicate that women have much less time available for using the solar dryer. However, the group discussions showed that women want to be involved in the process but are limited because of their lack of time due to their multiple work tasks at the farm, the association and at home. They are only willing to use the technology if it ensures an economic gain. We could see that some of the steps in the solar drying process are clearly gender divided. In addition, men tended to ascribe much more steps in the solar fruit drying process to themselves than to the women. Interestingly, results from the women's group indicate that several steps that were new to them – related to the handling of the bags and the solar dryers – were not specifically gender divided, which can present an arena for researchers to overcome traditional gender roles and ensure that from the beginning of the project, there is a gender equal interaction with the technology.

The study shows that solar drying could influence young girls negatively and that this needs to receive special consideration in further project operation. We discussed potential mechanisms and tools that can be applied by development practitioners to become more aware of the risk to reproduce traditional gender roles and unequal gender relations with the development of new agricultural technologies and how to reduce this. However, there is no quick fix since traditional gender roles and unequal gender relations are based on social and cultural norms that can be changed slowly over time. Nevertheless, these tools can provide an enabling environment.

Furthermore, based on the theory of intersectionality, we argue that development practitioners should pay much more attention to the spaces where technology development and training take place since the ascribed social roles tend to be context dependent. By moving technology development projects to a neutral context, the

farmers might be less inclined to fall back to their traditional roles and could instead develop new roles in conjunction with the new technology development. However, this still does not ensure how these newly negotiated identities can be transferred to the old spaces – that are still defined by the intersectional identities of the dominant groups – but they can build a solid foundation from which new configurations of identities can cross over.

Notes

1. Approximately double compared to Berlin and Copenhagen in Europe with 1000 kWh/m^2/year. This was calculated with the software Meteonorm (www.meteonorm.com).
2. Roasted cassava root flour, which is a common meal in many African countries.
3. The number of men and women was not equally divided. However, this study does not aim towards a statistical analysis and general representation but rather aims to capture the individual perceptions of the farmers involved in both associations where the solar dryer is planned to be installed.
4. Children were never placed first but second and third in the different tasks by women and men. The figures reflect these values.

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Notes on contributors

Pia Piroschka Otte is a senior researcher at Ruralis - Institute for Rural and Regional Research. Her research focuses on energy transitions and climate change in cross-cultural contexts.

Lucas Daniel Tivana, PhD in food engineering, is a lecturer and researcher at Eduardo Mondlane University, Mozambique. His research is focused on developing post-harvest technologies suitable to small-holder farmers in Sub Saharan Africa.

Randi Phinney is a PhD candidate at Lund University. Her research is focused on developing robust and sustainable food preservation technologies for tropical countries like Mozambique.

Ricardo Bernardo is a lecturer at Lund University within the field of solar energy technology and energy efficient buildings.

Henrik Davidsson is an assistant lecturer at Lund University within the field of solar energy technology and energy efficient buildings.

ORCID

Pia Piroschka Otte http://orcid.org/0000-0003-4368-525X
Lucas Daniel Tivana http://orcid.org/0000-0002-0905-8829
Randi Phinney http://orcid.org/0000-0002-2712-9328
Ricardo Bernardo http://orcid.org/0000-0002-8156-5323
Henrik Davidsson http://orcid.org/0000-0002-1401-7685

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