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Women's Access to Agricultural Technologies in Rice Production and Processing Hubs: A Comparative Analysis of Ethiopia, Madagascar and Tanzania

Esther L. Achandi[a,b], Gaudiose Mujawamariya[a,c,*] , Afiavi R. Agboh-Noameshie[d], Shewaye Gebremariam[e], Njaka Rahalivavololona[f], Jonne Rodenburg[g,h]

[a] *AfricaRice Center (AfricaRice), Dar es salaam, Tanzania*

[b] *University of Dar es Salaam, Dar es Salaam, Tanzania*

[c] *AfricaRice Center (AfricaRice), Antsirabe, Madagascar*

[d] *AfricaRice Center (AfricaRice), Cotonou, Benin*

[e] *Fogera National Rice Research and Training Center, Fogera, Ethiopia*

[f] *Centre National de la Recherche Appliquée au Développement Rural (FOFIFA), Madagascar*

[g] *AfricaRice Center (AfricaRice), Abidjan, Côte d'Ivoire*

[h] *Natural Resources Institute (NRI), University of Greenwich, Chatham Maritime, Kent, UK*

Abstract

This study presents results from a farmer survey conducted with 560 rice farmers from 27 villages spread over five hubs (concentration areas of rice production and processing) in three different countries in Eastern Africa (Ethiopia, Tanzania and Madagascar). The main research objective was to assess women's access to rice technologies and constraints to adoption of technologies. Constraints were analyzed over five different categories: (1) institutional (2) access to agricultural inputs, (3) technology-contextual, (4) household and socio-cultural and (5) extension. Key providers of extension were public (government), Non-Governmental Organizations (NGOs) and international organizations. Our study identifies that the

[*] Corresponding author. Mikocheni B/Kawe, P.O. Box 33581, Dar es Salaam, Tanzania.
E-mail address: G.Mujawamariya@cgiar.org (G. Mujawamariya).

overarching constraints to technology adoption are institutional and cultural impediments and related to the mode of delivery of extension services. Furthermore, the Focus Group Discussions (FGD) with the women, revealed that empowerment of women in decision making at the household level can enhance women's access and engagement in better farming practices suggested under extension advisory services. This is specifically true where women are able to overcome the hurdles of acquisition of extension training and access to the improved technologies.

Highlights

• Institutional, cultural, contextual and extension delivery hurdles curtail adoption.

• Women empowerment enhances access to and engagement in better farming practices.

• In gender unequal cultures, female extension agents must be promoted.

• Women participation in technology design can prevent potential excess drudgery.

• Gender-sensitive extension framework can significantly draw women to adoption.

1. Introduction

Agricultural extension and rural education are emphasized by development experts as crucial in achieving agricultural development, poverty reduction, and food security (Rivera and Qamar, 2003). Extension and advisory services are the main channels for delivery of information and new agricultural technologies to resource poor farmers. They form key vectors for technology dissemination (Adesina et al., 2000; Feder et al., 1985; Quisumbing & Pandolfelli, 2010).

Within rural farming systems, extension services often do not effectively reach women. Women are also often denied equal access to productive resources like modern agricultural inputs, technologies and credit systems (FAO, 2011; Owolabi et al., 2011). In addition,

women particularly those in male-headed households tend to participate less than men in formal activities like training, cooperatives, and official meetings (Lahai et al., 1999). Correcting this situation would substantially benefit rural economies and food security in developing countries. FAO (2011) showed that if women had the same access to productive resources and services as men, they could increase production on their farms by 20–30 %. This increase could raise total agricultural output in developing countries by 2.5–4 % and reduce the number of hungry people in the world by 12–17 %. Furthermore, when women's productivity and incomes increase, the benefits rise across families and generations, because women are known to devote a larger fraction of their incomes to their children's health, nutrition and education (Mehra, 1997). Understanding the role of women in agricultural production is critical in designing agricultural policies that increase productivity and reduce poverty. One needs to get insights into the constraints to the adoption of new technologies by women and whether they are indeed systematically left out or disadvantaged by the introduction of such technologies (Doss, 2014). It is obvious that gender inequalities in technology delivery impose real costs on societies in terms of untapped potential leading to suboptimal agricultural development (Ragasa, 2012). The main reason behind the exclusion of women is that extension services are often designed and disseminated by men who do not necessarily regard women as part of their target group (Lahai, 1999). Furthermore, they do not take women's productive and reproductive roles[†] and preferences into consideration (Manfre et al., 2013). Such preferences include for instance the choice to work with female extension officers with whom women farmers can more easily discuss their problems (e.g., Due et al., 1997). In general, extension systems seem to view women as welfare beneficiaries, rather than

[†]Productive work includes primary production activities (agriculture, animal husbandry, fishing, forestry, fetching of water and collection of fuelwood); employment; services and other production of goods (e.g., food processing, trade, business).Activities such as water collection, child care, cooking and washing clothes are reproductive (FAO et al., 2010).

key actors in agricultural production (FAO, 2011). Even in cases where women are provided with extension services, the male-centric nature of technology information services — resulting from the inadequate sensitization of extension delivery personnel on the importance of gender-division of labour and gender-relations— reduces their relevance for women. This in turn curtails the impact these services could have on behavioral and technological innovations among this group of farmers. Empirically, Chizari et al. (1997) proved that the lack of access to extension by women in rice production activities in Iran resulted in significantly lower productivity and incomes compared to the situation in which extension would have reached them.

While much emphasis is put on extension, other modes of exposure to new technologies are popular such as radio, television, internet, and mobile phone services (Nyaga, 2012). Therefore, there is a need to assess the constraints to technology adoption in a wider sense. Second, the extent to which the participation of women in extension activities, and their acquisition of information and knowledge through these activities, is affected by the design and dissemination framework should also be investigated.

The above aspects are studied in the general context of technologies associated with rice farming. Such technologies are related to good agricultural practices (e.g. selection of improved varieties, adequate and timely fertilizer application, timely weeding) or to reducing the drudgery of important agricultural operations (e.g. power tillers, rotary weeders, harvesters and threshers). Although such technologies exist, generally there are gender differences in access and adoption due to problems associated with (1) access to necessary associated inputs and services (including fertilizer, access to information and credit), (2) physical accessibility and affordability of transport services necessary to attend meetings, trainings and extension

services, (3) the risk perceived by women of shifting control over profit and assets from them to the male domain and the probable loss of livelihoods for poorer or landless women who used to be hired for services that are replaced by the new technology (Ragasa, 2012).

The current study was conducted in Ethiopia, Madagascar and Tanzania, where government and non-government actors have been actively investing in agricultural extension systems for the past years (Rutatora and Mattee, 2001). Various attempts to reach more women farmers have been implemented, such as the "women's development package" in Ethiopia (Legovini, 2005) and the Farmer-to-Farmer extension developed by the Farmers' Groups Network (MVIWATA) in Tanzania (Mbo'o-Tchouawou and Colverson, 2014). The intensity of implementation of gender policies in agriculture may however differ across countries.

The specific aim of this study is threefold: (1) make a typology and assessment of existing technologies and practices in rice farming available to farmers in particular those promoted by extension, (2) identify the specific constraints limiting adoption of rice farming technologies by women and (3) assess the role of extension in technology delivery and the importance of the gender of the extension agent therein.

2. Methodological Approach

2.1 Method and data collection

The study was conducted in the Rice Sector Development Hubs[‡] ('hubs') of Ethiopia, Madagascar and Tanzania between June 2014 and December 2015. Rice Sector Development Hubs represent key rice ecologies for each country. They involve large groups of farmers and other value chain actors. Within each hub are villages where different rice development

[‡] A hub is a zone where rice research products, services and innovations are integrated across the rice value chain to achieve development outcomes and impact. The hub includes farmers, millers, input dealers, traders.

activities are conducted (agronomy, mechanization, participatory variety selection and training on seed production) and counterfactual villages where no interventions are undertaken[§]. In Madagascar and Tanzania, two hubs are operational (Ambohibary and Ankazomiriotra in Madagascar, Kahama and Kilombero in Tanzania) whereas in Ethiopia, only one hub is operational (Fogera). In Madagascar and Tanzania, three agronomic intervention villages and two counterfactual villages were randomly selected in each hub. In Ethiopia, the study was conducted in five agronomy intervention villages and two randomly selected counterfactual villages (Table 1)[**]. From each village, the 10 rice producing households which were previously selected for the hub baseline surveys were invited to participate in the current study. The household head and his wife (if she is not the actual head of the household) were invited to participate in the study. Focus group discussions were organized in each selected village and used to collect information on aspects of rice production and postharvest technologies, delivery and extension from households. Here, gender disaggregated data were gathered by dividing farmers into two groups with men and women having separate sessions for discussion. At the end, individual interviews were held with women on their empowerment vis-a-vis extension service access. Additional information was collected from the village extension officers to compile a list of technologies introduced to the village and the perception and performance of male and female farmers concerning the available technologies. Table 1 describes the study sites, number of villages and number of farmers and extension workers surveyed.

Table1. Study sites, number of villages and number of farmers surveyed.

	Ethiopia	Madagascar	Tanzania	Total

[§] The selection of villages is intended to 'provide feedback to researchers and policy makers on technology performance and research and investment priorities' (Wopereis et al., 2013). A total of 32 interventions villages are already selected for agronomy (5 villages), mechanization (5 villages), participatory variety selection (5 villages) and training on seed production (7 villages). Ten (10) villages were additionally retained as control. From each village, 10 rice producing households were selected for baseline surveys (conducted in 2014-2015) and regular monitoring.

[**] Fact sheet and other details on each hub can be found at http://www.ricehub.org/.

Hubs	Fogera	Ambohibary Ankazomiriotra	Kilombero Kahama	5
Number of villages	7	10	10	27
Total number of farmers in focus groups	140	245	175	560
Number of female respondents	67	124	81	272
Number of extension workers*	7	10	10	27*

* One extension worker per village

Respondents were aged between 27 and 70 years old, more than 80% were married and the majority has attained primary education except in Ethiopia where the majority of the respondents either only underwent informal adult education, or were completely illiterate. No variation is expected within the 'population' of the hub with regard to technology access and usage and extension delivery, hence the samples are representative of the targeted ecologies. Additionally, in both hubs there were villages that benefit from interventions from development partners in terms of advancing technology adoption.

The collected data were mainly in qualitative and descriptive form focusing on gender relations, perceptions and constraints based on the understanding of the respondents. During the interviews in Tanzania, qualitative data were collected using an audio recorder and the discussions were conducted in the local or most spoken language. They were later transcribed and translated into English. Subsequently, the data were imported into ATLAS.ti[††] for analysis: codes were created to cluster the available information into key constructs that could be analyzed and interpreted (Friese, 2014). Fixed constructs were used as guidelines in collecting information across Madagascar and Ethiopia, while additional aspects and farmers' precisions

[††]ATLAS.ti GmbH, Berlin (ATLAS.ti: The Qualitative Data Analysis Software, Scientific Software Development. Available at http://www.atlasti.com)

were noted alongside. To analyze the quantitative data, descriptive statistical techniques like frequency counts were used and means and percentages were calculated.

2.2. The Women Empowerment Index

We adopted a simple Women Empowerment Index suggested by Paris et al. (2008) to analyze the level of participation of women in decision-making within the household. A Women Empowerment Index in Agriculture (WEI) adapted to rice farming systems was constructed. A WEI shows the level of empowerment as associated with the ability to make decisions, and to have access to material and social resources needed to carry out those decisions, on matters related to agriculture as stipulated by Alkire et al. (2013). The activities and attributes of decision-making over which the WEI is computed are listed in Appendix 1.

The WEI was calculated as:

$$WEI = \frac{1}{d}\sum_{i=1}^{N} x_j$$

Where N is the total number of activities that are listed for which decisions in rice farming are made, x is the value of decision-making on the j topic and d is the total number of decisions given by the respondent.

The index ranges from 1 to 5, whereby the two extremes indicate that either the husband (WEI=1) or the wife (WEI=5) makes all decisions in the household solely. A WEI of 3 indicates that the woman and man within the dual adult household have an equal say in terms of decision-making in the household. The average index was computed at the country level over the indicated responses.

3. Results and Discussion

3.1 Women Empowerment

Madagascar reported the highest attainment of empowerment for women (WEI=3.3). Ethiopia showed the smallest index (WEI=2.3) indicating a lower involvement of women in decision-making as compared to men. Tanzania was intermediate with a WEI of 2.9. In Madagascar, decision-making is jointly undertaken by the husband and wife; within the sample, women hold a relatively more dominant position than men. Women decide mostly on aspects of variety choice, distribution of varieties and crops across plots, seed preparation, and weeding. The husband is more involved in crop management including land preparation, planting date, use of fertilizers and other agro-chemicals, and supervision of farm workers. Both husband and wife jointly participate in decisions regarding harvest and post-harvest operations, rice marketing, livestock rearing, various expenses and investments. In Tanzania, women are mainly involved in rice production while post-harvest (threshing, drying, and milling) and marketing activities are mostly done by men.

In Ethiopia, legally women and male have equal rights to land ownership. However, in general, the involvement of women in decision-making is very limited especially in purchase and application of agricultural inputs and land usage. They participate more in decisions regarding the variety choice, rice marketing (quantity and time to sell rice), food purchase and other household expenses. The explanations of the women's limited participation by male and female farmers are: (1) the cultural assumption that they are merely wives of farmers but not farmers in their own right, (2) women do not value the various tasks that they do in the household and on farm, and (3) women lack control over key resources including land.

These explanations are supported by the literature. Women in Africa and in Asia are indeed at times not perceived as farmers despite the important roles they play at the farm level (Ajah, 2010; Galiè et al. 2013). Women also tend to undervalue their own contribution; this is a

result of the patriarchal cultural system that views women as simply playing a 'support' role to the husband (Erman et al., 2002; Gella and Tadele, 2015; Rathge, 1989). The lack of control over resources is not unique to Ethiopia. Indeed, it has been argued that most land titling in developing countries is done at the individual level, with the misconception that women are not farmers and hence not interested in owning land (Agarwal, 2003). Moreover, women's joint ownership of land (and other productive assets) only depends on the relationship with the male. As a result, because much of the rural agricultural land is under customary land tenure system, in patrilineal societies, women cannot simply own customary land in their own right (Tripp, 2004).

3.2 Typology and evaluation of existing technologies and practices in rice farming available to farmers through extension

3.2.1 Cross-country comparison of practices and technology in rice farming

Technologies and practices in rice farming operations that farmers have been exposed to across the study countries are listed in Table 2.

Table 2: Existing rice farming technologies and applied practices in Ethiopia, Tanzania and Madagascar

Existing technologies	**Ethiopia**	**Tanzania**	**Madagascar**
Seed selection	Rice stand at harvest	*Experience in sorting seeds *Soaking seeds *Quality seed from agro-dealers	*Stand at harvest *First grains during threshing
Land preparation	Draft animal	Hand hoes, plow, power tillers, tractors	Spade, power tillers, plow
	Constructing bunds	Constructing bunds	
Planting			
Direct seeding	✓	✓	✓
Transplanting		✓	✓
Weeding			
Manual weeding	✓	✓	✓
Rotary/push weeder	✓	✓	✓
Herbicides		✓	
Fertilizer application			
Nursery			✓

Field: Organic fertilizer			✓
Field: NPK/Urea	✓		✓
Pesticides			Applied on seeds
Bird scaring	Cassette thread	Cassette thread Slings and kites	Cassette thread
Harvesting and Post-harvest management			
Sickles	✓	✓	✓
Harvester			✓
Thresher			✓
Sunlight for drying	✓	✓	✓
Storage bags	✓	✓	✓
Traditional silo	✓		
Milling	Machine	Machine	Machine, mortars

It is evident that there are common practices and technologies in rice farming, but also important differences between countries. For instance, selection of seeds for the subsequent season is done during harvest in Ethiopia while in Madagascar, it is done by observing the rice stand. Farmers use certain selection criteria such as 'absence of diseases' and 'good panicle length'. In Madagascar, the first grains to fall off at threshing are also retained, but in Tanzania, grains are sorted or soaked in salty water to determine which seeds are viable for planting.

In land preparation, animal traction is used in Ethiopia, but labour intensive methods are used elsewhere including the use of plows and spades in Madagascar, or hand hoes and plows in Tanzania. In Tanzania, power tillers and tractors are also used. For the purpose of retaining water within the rice fields, bunds are commonly constructed. Different planting methods are applied. Direct sowing by broadcasting was traditionally applied in Ethiopia, the new technique currently applied is seeding by hand drilling. In Tanzania sowing is done by broadcasting the seeds, but transplanting is becoming more and more widely practiced. Drilling and transplanting reduce the seed rate, lead to strong plant vigour, and facilitate weeding especially when done in lines compared to traditional broadcasting (Rodenburg et al., 2015; Rodenburg and Johnson, 2009). However, transplanting requires preparation of a nursery in

advance. Manual weeding is common in Tanzania and Ethiopia, although rotary/push weeders have been introduced in recent years. These mechanical weeders save on labour and time (Rodenburg et al., 2015; Krupnik et al., 2012). In Madagascar, mechanical weeders are more frequently observed than in other countries. The weeders are used by men, while women do complementary weeding by hand after the row-passage by the weeders.

The use of inorganic fertilizers is limited, especially in Tanzania. In Madagascar, NPK and urea are applied both in the nursery and in the transplanted rice fields while in Ethiopia where there is direct seeding, inorganic fertilizer is also applied to the rice fields. Organic fertilizer is applied in the rice fields in Madagascar too. Pesticides are not used apart from occasional seed treatment in Madagascar. Across the countries, bird scaring is done with cassette threads but slings and kites are used as well.

Sickles are used in harvesting. In the three countries, harvesting machines were introduced, but, it is only in Madagascar where harvesters are being used. Threshing is done manually; the common method in the three countries is to beat rice spread on a prepared floor with a stick/club. In addition, in Ethiopia, threshing is done mainly by animal trampling. Beating with clubs /stick on a prepared floor is done rarely. Pestles are used in Madagascar alongside beating rice against a metal drum or stone. Drying is done under direct sunlight. In Tanzania, tarpaulin (large jute coated sheet) is spread on the ground for drying paddy whereas in Madagascar, drying is mostly done on the floor coated with cow dung. The tarpaulin sheets also serve to prevent contamination of paddy by stones and other impurities. Storage is done in air tight bags which are said to preserve the moisture content of rice and protect it from weevils; however, granaries (prepared from mud) are still commonly used in Ethiopia. The germination percentage of the seed stored in sacks is very high and in terms of milling, their

breakage rate is very low. Milling in Ethiopia and Tanzania is done with machines that differ in terms of capacity and milling quality. The use of mortar and pestle is however still common in Madagascar. Milling rice with a machine allows for collection of the rice bran that is used as poultry and livestock feed.

3.2.2 Gendered division of labour and technology use in rice farming

While the above technologies are known to both men and women, similarities and differences exist between them in usage or performance. For instance, in seed selection in Tanzania, both men and women agree that selection based on soaking seeds in water increases yield. However, on the issue of which seeds should be soaked, women are merely content with seed recycling which is simply retaining seeds from the previous season while men indicated that it is better to use quality seed purchased from agro-dealers. In land preparation, hand hoes, ox-plows and power tillers are the tools mentioned by both men and women in Tanzania. Men confirmed that the power tillers are easy to use and indeed simplify work; however, women are more concerned about the cost associated with acquiring the equipment. According to women, the more efficient power tillers require capital to purchase. In all the countries, the technology commonly used for land preparation is the plow which both men and women acknowledge as having some benefits. Women perceive cost reduction as an advantage of ox-plowing, compared to the use of hand hoes, whereas men add that it reduces labour required.

In sowing, both male and female farmers in Ethiopia acknowledge the benefits of row drilling to reduce the seed rate and to make weeding easier. In Tanzania, both men and women confirm that they broadcast rice or use rice seed dibblers. Women however argue that planting in rows makes weeding much easier. In Madagascar, transplanting is appreciated by both men

and women in reducing labour time. Women specify that with square planting patterns, transplanting takes 2 hours per 100 square meters (0.025acre).

For weeding, rotary weeders are used by men and women in Ethiopia; they are appreciated because they reduce time and labour compared to hand weeding. In Tanzania, hand hoes are used by men and women for weeding, while herbicides are only used by men. This concurs with an earlier study on parasitic weed management in rice in southern Tanzania, where herbicides were identified as a gender-biased technology (Tippe et al., 2017). Men are also benefiting more from rotary weeders, which are introduced by external projects and NGO's. The rotary weeders are not yet widely available to all farmers, but according to the users, they simplify work. Women add that they mostly weed by hand, and that this is even needed after the use of rotary weeders to remove the remaining weeds in the rows. In the similar assessment done in Madagascar, men easily confirm the benefits of using weeders in reducing time and cost while women admit that manual weeding is still widely done.

In Ethiopia, both men and women have the same views regarding the application of fertilizer which is to increase yield and the bi-products (straw). However, women add that it is better to apply it through row drilling as this method minimizes fertilizer losses. In Tanzania, men and women are in agreement with regards to the benefits of using fertilizer (increase yield) and the method (broadcasting). In Madagascar, only men could reveal the advantages of using fertilizer because they are the ones who make the decision on fertilizer application as noted during the empowerment analysis. According to them, fertilizer strengthens plants for faster growth; specifically, organic fertilizer makes the soil more productive. Men in Madagascar also explained that pesticides are better applied at seeding stage to protect

seedlings. In Tanzania, men and women confirm that pesticides reduce the incidence of pests. Men added that pesticides scare away birds and hence reduce the related loss.

Threshers are available in Madagascar. Men and women value them because they reduce labour time, labour cost, grain loss and they deliver better quality than manual threshing. Quality is also determined by the drying process. In Tanzania, men and women stated that they use tarpaulin sheets to dry rice. In Madagascar where drying on the floor is still widely done, the plastic sheets are found easy to use. Here, men add that drying on plastic sheets results in better quality rice and the losses are also reduced. Lastly, the evaluation of practices in storage of rice by male and female farmers in Ethiopia reveals the advantage of using air tight bags namely to conserve the paddy's moisture content and protect it from weevils. As a result, the milling recovery is high and the seed germination percentage is high. In Tanzania, both men and women simply declare that the plastic bags and sacks are safe and easy to use. In Madagascar, the assessment is done by men that storing rice in plastic bags leads to better conservation, protection against pests and chickens. It also enables the farmer to know the exact quantity of rice he holds.

3.3 Constraints to technology adoption by women farmers

Although the above technologies have been cited as available, the women's focus groups cited several constraints to adoption of some of these technologies. Table 3(a-e) illustrates the five categories of constraints identified in relation to technology adoption: (1) institutional constraints, (2) access and control of agricultural inputs, (3) technology-contextual constraints (4) socio-cultural constraints, and (5) agricultural extension. These constraints are explained by the statements of the survey participants.

3.3.1. Institutional constraints to technology adoption, perceived by women

Table 3a. Institutional constraints to technology adoption in three countries (Ethiopia, Tanzania and Madagascar).

Constraint	Ethiopia	Tanzania	Madagascar
Capital & credit	Lack of sufficient capital and credit facilities to access recommended technologies under extension	Problem to access to funds	Lack of capital, difficulty to access credit
Farmers' group		Absence of women groups means that they are not included in decision-making	No farmers group
Infrastructure	Improper infrastructure to access good markets	Low quality of infrastructure	Infrastructure inadequate, bad state of communication channels
Market		Difficult access to markets	

The lack of capital is one of the constraints limiting technology adoption. Related to this is the lack of access to credit. As a farmer in Madagascar puts it:

> *"If the recommended new technology requires a fairly large investment, its adoption is hindered by a lack of funds and difficulty in accessing credit."* (Ambohibary)

A second important impediment to the adoption of new technologies identified by the participants is the lack of women farmer groups:

> *"Absence of women's group is a hindrance to adoption of technology because there are no means of sharing information and skills as can be done in groups"* (Kahama)
>
> *"You can't form a group if you have no tools; it will be wastage of time"* (Kahama)
>
> *[There is …] "no inclusion of women in decision-making"* (Kilombero)

The lack of functional markets and good roads is another frequently narrated reason.

> *"The lack of markets is a serious problem to farmers"* (Kahama)

"Markets are far away from here…buyers come here to purchase our crops at very low prices" (Kahama)

"[…] due to high transportation cost to our village, the price we receive for our produce is reduced" (Fogera)

"Roads are impassable" (Kahama)

"The roads are sometimes perilous" (Ankazomiriotra)

Women also complain that they are not included in the decision-making processes or that their voices are not heard. They also confirm that they have no access to sufficient or good-quality land.

"We have time —to participate in village meetings on agriculture—, but no one involves us in decision-making" (Kahama)

"Our plots are too small and we cannot expand anymore" (Ambohibary)

"…the state does not encourage the use of public land" (Ambohibary)

Many of these institutional constraints have been identified before. For instance, the lack of financial capital has been cited as a limitation to technology adoption (Chi and Yamada, 2002; Feder et al., 1985). The absence of women's groups reflects a lack of social capital. Being organized in a group is important to women to acquire access to productive resources and exercise "agency" through collective action which would not have been possible if they acted as individuals (Quisumbing and Pandolfelli, 2010).

3.3.2 Input constraints to technology adoption, perceived by women

The limited availability and access to labour and land, and the high costs of inputs are among the most eminent overarching constraints mentioned by the farmers in this survey (Table 3b).

Table 3b. Agricultural inputs constraints to technology adoption, perceived by women in Ethiopia, Tanzania and Madagascar.

Constraint	Ethiopia	Tanzania	Madagascar
Labour	Lack of sufficient labour for operations suggested under extension.	Lack of sufficient manpower so usage of some tools is difficult	*Lack of adequate manpower for operations suggested by the technical advisory support service. *Lack of sufficient funds to hire labour
Land	*Inability to access land *Lack of decision-making power over the land.	Inability to access land	*Low availability of land *Prohibition to use public land *Small size of plots
Water			Access to water is not timely
Access		Some women do not have tools	
Cost		High cost of agricultural inputs suggested under extension	High cost of agricultural inputs (fertilizers and materials)

Agricultural input constraints such as lack of sufficient labour, inability to access land and lack of decision-making power over land all pose major hindrances to farmers in accessing and adopting new technologies. Rice activities are largely labour intensive and new innovations such as planting in lines require much more labour (as highlighted by the farmers in Tanzania) than the traditional broadcasting at the crop establishment phase thus making it hard to adopt the technologies. Morris and Doss (1999) show that gender-linked differences in the adoption of modern maize varieties and mineral fertilizers in Ghana result from gender-linked differences in access to complementary inputs; women face difficulties in accessing labour — especially male labour— for such activities as land clearing. Furthermore, land tenure affects the kind of investments that farmers can make on land especially if it is perceived unsecure or if the farmer is not sure of how much longer the land will be available (Tenaw et al., 2009). Moreover, the limited access to land is a hindrance to women in adoption of technologies as

confirmed by Doss (2001). The lack of water has been argued to be tied to lack of access and decision-making power over land for women. They are usually unable to assert themselves in demanding irrigation water and water for domestic use (Ragasa, 2012).

3.3.3. Technology-contextual constraints to technology adoption, perceived by women

Perceived risks, uncertainty about the outcomes, time constraints and availability of the technology are mentioned as the most dominant technology constraints to adoption by women farmers in the three countries (Table 3c). The definition of these constraints varies however from country to country. In the hubs in Tanzania only the lack of time and technology availability are mentioned as constraints. In the hubs of Madagascar and Ethiopia the perceived risks and uncertainty associated with the technology seem important constraints to adoption, and these fears are partly fed by the lack of proofs of success, for instance from demonstration plots.

Table 3c. Technology-contextual constraints to technology adoption, perceived by women in Ethiopia, Tanzania and Madagascar

Constraint	Ethiopia	Tanzania	Madagascar
Risk	Too risky to try new technologies		The testing of new technologies is perceived as too risky: psychological effect of change
Time	Time consuming and tedious nature of the proposed methods under extension.	Time requirement	
Climate			*Risk associated with natural calamities * New varieties depend on climatic conditions
Cost		*High cost of technology	
Availability		*Needed technologies are not available (e.g., row planter, weeder, harvester, miller)	The proposed technologies are not always available
Success	*Farmers unable to		*Lack of demonstration

	perceive impact of technology *Lack of 'proof of concept' or 'lack of certainty that the technology will be successful *Technology does not give the promised results	plots *Inability to perceive the impact of technology especially when the promised results are not obtained

"Due to lack of demonstration plots we cannot see the benefits of the technology" (Ambohibary)

"... it is only the farmers owning plots next to the adopters who can observe the results" (Ambohibary)

"...if the recommended technology is uncertain, we can't adopt it because our livelihoods are completely dependent on the farm" (Fogera)

Lack of proof of success of the technology and lack of demonstration plots have been cited as limiting factors in female farmers' adoption of new technologies. This can be categorized as existing information asymmetries as cited by Uaiene et al. (2009). Once this asymmetry is solved, the women would be able to adopt the new technologies.

Women have been noted to adopt new technologies much slower than men (Ragasa, 2012; Van Eerdewijk and Danielsen, 2015). This is mainly due to their differentiated access to the required complimentary inputs as compared to men. Therefore, addressing information/ communication flows and complementary inputs would boost their adoption of new technologies.

3.3.4. Socio-cultural constraints to technology adoption perceived, by women

Among the social-cultural constraints, the low level of education is observed to be the single most important reason for refusal or hesitation of technology adoption (Table 3d). The

advanced age of the farmers and cultural perceptions and norms —associated with male dominance and resistance to change— are perceived as adoption constraints in Madagascar and Ethiopia. Inclination towards the familiar traditional methods of farming also hinder the adoption of new technologies by women farmers.

Table 3d. Socio-cultural constraints to technology adoption perceived, by women in Ethiopia, Tanzania and Madagascar

Constraint	Ethiopia	Tanzania	Madagascar
Age	Age of farmers		Old age, thus lack of the will to change
Education	Low level of education of farmers	Lack/low level of education	Low level of education of farmers
Culture	*Husband's negative perception of technologies suggested under extension * Most women undervalue their involvement in agriculture and thereby have lower participation in decision-making towards obtaining agricultural technologies and inputs		*Need for husband's approval before adopting the technology. *Resistance to change

"Majority of us are around 50 years of age" (Ambohibary)

"Most of us are inclined towards traditional methods of farming" (Fogera)

Observations in the current study, on age as cause for reluctance of technology adoption, are supported by Chi and Yamada (2002), who concluded that older farmers are more conservative and therefore less likely to adopt new technologies because of the associated innovation risk. The adoption of new technologies indeed involves taking a risk for the farmer. Furthermore, women often have to seek permission from their (male) household or village heads to be able to use new technologies (Tenaw et al., 2009). This is linked to the lack of decision-power by women within these contexts.

"Inability to make decisions has a negative effect on the adoption of new technologies… when you decide to sow by lines and your husband doesn't want that, what will you do? If he refuses there is nothing I can do" (Kahama)

3.3.5. Extension constraints to technology adoption, perceived by women

There were seven broad categories of adoption constraints related to extension services (Table 3e). Farmers mentioned the limited number of extension agents and the high turn-over rates of extension staff as constraints. Another important constraint for women is that very few extension agents are women, and the transfer of information is often hampered when the extension agent has a different sex from the farmer. Farmers also noted that the transferred information is inadequate because of the low frequency of visits and the suboptimal timing and because of the lack of demonstration plots at a centrally designated location.

Table 3e. Extension constraints to technology adoption, perceived by women in Ethiopia, Tanzania and Madagascar.

Constraint	Ethiopia	Tanzania	Madagascar
Few agents		Limited number of agricultural officers: ALL are male	Few extension agents
Agent turnover	High level of extension agents' turnover.	Frequent transfers of agricultural officers in some villages	Lack of technical advice
Sex of agent	*Discomfort of farmer with the sex of the extension agent (Women prefer women and men prefer men) *Cultural impediment: women especially primary male headed household wives are not allowed to approach freely male extension officer to have extension advisory service as alone *shortage of women extension officers;	Limited number of agricultural officers: ALL are male	
Lack of demonstration	Non-exposure to demonstration fields	Non-exposure to demonstration fields	Delivery mode

Training location	Lack of centralized training location for farmers to meet with extension officers	*Lack of a designated agricultural training center in the village for farmers. *Lack of permanent training place	Infrequent visit by extension agents
Information	Lack of sufficient information to be able to apply	Agricultural information does not reach farmers on the right time, there are a lot delays.	*Mouth to mouth transfer of information distorts message *Insufficient information as agents pass 1 to 2 times per year
Culture	*Lack of extension advisory service for females farmers given the assumption that information would be passed on from the husbands to the wives	Wrong perception of woman working with man	

In Ethiopia, in most households with primary male household heads, female farmers do not have access to agricultural extension advisory services because the head of the household is the one that participates in the training. In Tanzania however, extension services are provided to both male and female farmers by the government, international organizations such as Oxfam, through direct interaction with farmers. Yet, cultural impediments remain important here as well (see the following quote).

> *"... for example, if the officer is a man, do you think my husband will understand if I tell him that I'm going to the field with the extension officer?"* (Kahama)

In Madagascar (*Ambohibary),* the lack of demonstration plots appears to be a big hindrance. Such demonstrations are important because farmers 'want to see and have tangible results before applying the new technologies'. Furthermore, the extension service was assessed to be lacking in *Ankazomiriotra* in terms of the number of extension agents and the advice provided.

In Ethiopia the content of the information provided by extension is fine but some methods of advisory services do not reach all farmers. Training should consider all farmers. Extension service follow-up should be instituted to help farmers exercise what they learn from different advisory service methods. Training is also sometimes given but not supported by practical sessions.

In Tanzania, the content of the extension information is fine but it does not reach farmers at the right time, there are lots of delays. Access to extension services alone is not enough however; rather the decision-making power over what can be done with the extension knowledge accessed is paramount in improving agricultural production by the farmers. FAO (2007) indicates that women are dramatically under-represented in decision-making bodies (from household-level up) because of their general poorer level of education, lack of confidence and greater workload. Indeed, Mehra (1997) confirms that women were inhibited from accessing extension. This is in spite of the important role they play in the provision of labour for agriculture. The lack of extension advisory services that specifically targets women is partly the result of the (implicit) assumption that information would be passed on from the husbands to the wives (Durutan, 1994). It has been argued that women are usually unable to access extension advisory services due to several limitations and to the predominant extension framework usually views women as secondary. Consequently, the male household heads are targeted by extension services (Durutan, 1994). The issue of undervaluing women's own contribution witnessed in agriculture has also been observed in other fields as highlighted by Haynes and Heilman (2013).

3.4 Assessment of extension delivery

In the assessment of the extension delivery services, the importance of central locations was observed in Tanzania and Madagascar (Table 4). A centralized location of the extension office is preferred by farmers. Another important point is the gender of the extension agent. In Ethiopia the majority (70%) of women farmers preferred a woman as extension agent, whereas in Tanzania and Madagascar this was 50%.

Table 4. Extension system, assessment and gender preferences in Ethiopia, Tanzania and Madagascar.

Aspects of extension system		**Ethiopia**	**Tanzania**	**Madagascar**
Source		Public and NGO	*Public, *International organizations e.g. Oxfam	Public and NGO
Number of officers per village		2 to 6	3 to 7	1 to 4
Mode of delivery of services		As individual farmers or through groups	Training-visit Individual visit	As mixed gender farmer groups and as individual farmers
Assessment of extension	Men	Good (6 villages) Fair (1 village)	Good	
	Women	Good (4 villages) Fair (3 villages)	Good	
Preferred Sex of officer		Over 70 % prefer Female	50% of participants prefer the same-sex extension agent	50% prefer female, 40% prefer either, 10% prefer male.
Preferred delivery mode			*Only 20% of participants prefer the same sex training * Centralized location	Centralized location

It is interesting to note how empowerment is linked to gender preferences in extension. For instance, in Ethiopia where the empowerment index is lowest, the majority of women participants stated their preference for a female extension agent. In the other two countries with more or less balanced empowerment indices, the preference was much less pronounced.

The main source of extension advisory services is the public system. Across countries however, the public extension framework is plagued by problems of inadequate funding and bureaucracy (Rutatora and Mattee, 2001) which compromise its effectiveness. Women have limited access to agricultural extension services as compared to men (Oseni et al, 2015). Worse still, most public extension workers are men. Chizari et al. (1997) argue that many women do not get access to extension officers because there may be cultural inhibitions for male officers' interaction with women farmers and these services do not undertake enough efforts to reach female farmers within the household.

Women farmers should be given the opportunity to work with female extension officers with whom they feel they could easily discuss their problems (Due et al., 1997; Lahai et al., 1999). Our findings concur with this argument. For example, in Ethiopia the preference for female extension officers is explained by existing cultural barriers that discourage male extension workers from directly approaching married women farmers. Some studies have observed the restriction that cultural norms may have on women's access to extension services for as long as extension provision continues to be dominated by men (Oniang'o, 2005; Owolabi et al., 2011). Female extension officers are therefore likely to reach more women as has been suggested before (Chan, 2010).

In Tanzania, specifically in Kahama, the female farmers who prefer the female extension officer echo the same reason shared by the Ethiopian female farmers, i.e. that the female officer would be more understanding to their problems and needs (see quotes below).

"we want a woman to visit us for training and advice" (Kahama)

"we would prefer a female agricultural officer because a woman would understand us better" (Kahama)

"a woman…will help us in a friendly way to understand better new technologies on agriculture" (Kahama)

"we prefer a woman officer/expert… because we can explain to her about our problems/challenges, she would understand us" (Kahama)

" …she is humble, she knows the problems of women, she is not extravagant in utilizing agro- resources" (Kahama)

In spite of such preferences for female extension officers, the number of female extension officers is still small in Tanzania (Due et al., 1997; Isaya, 2016). However, unlike the Ethiopian farmers, the Tanzanian female farmers acknowledge that they receive adequate support by extension officers and that they are not considered less of a farmer in comparison to their husbands. This observation concurs with Isaya, (2016), who reported that Tanzanian women can freely access extension advice from the male extension officers. The observed preference for women extension is however also important in Tanzania, from an 'empowerment' perspective, as it is about the right and ability to choose. The expansion of freedom of choice is indeed an important component of empowerment (Do and Kurimoto, 2012).

In reviewing training, the female farmers in Tanzania prefer mixed group trainings instead of men-only or female-only groups so as to exchange ideas:

"*we want to expand our views by learning more from men rather than doing it by our own. We learn from each other; we are one people*" (Kilombero)

They are however cautious to add that:

"*...we women are fearful of men particularly our husbands, some of us can't dare to speak their mind in front of their husbands. Separate classes would work better"* (Kilombero)

Manfre et al. (2013) indeed observes that while single sex groups can empower women, mixed sex groups are important in enabling women to tap from men's networks, resources and information which women's networks usually lack.

In Ethiopia, with respect to the delivery mode, training is provided in different ways, e.g. at farmer's field school, exchange visits and information sharing with model farmers. The locations of these training sessions are most of the time the farmers' training centers, churches and sometimes in institutions. However, participation in extension information is limited to the household head who is normally the man. Women who are in male-headed households cannot participate in any training.

In Tanzania, there is no designated training venue and therefore training sometimes takes place at a school or in an open field. Moreover, the training sessions offered by agricultural officers are not enough. Farmers prefer training in a centralized location because it enables them to concentrate better (see quotes below).

"Going somewhere like Kahama town would work better because we have so much to do at home so if the training is conducted here you won't have time to concentrate"

"...we suppose that going somewhere else away from home would work better. If the training is conducted here we only give half commitment. This is home, you wake up and keep the house in order –cooking, washing the dishes and other stuff then after that you think about the training but if you go far from home all of your concentration will be on the training."

In Madagascar, there are very few extension officers and thus fewer visits to farmers. There is no centralized place to conduct agricultural training; the desire of farmers is to have such a place so that they can easily consult the extension officer whenever the need arises. According to farmers in Madagascar, the sex of the agent does not matter. Relevant are the technologies and practices shared and how relevant and sustainable they are. A program can be envisaged for trainings, visit-exchanges, radio programs and supporting instruments.

In general, as illustrated above, the lack of training facilities has been an impediment to the access of extension services by farmers, confirming previous findings by Thanh and Singh (2007) in Vietnam and India. Other identified problems are the delay in the delivery of extension services attributed to delays in availability of funds, and the insufficient number of training sessions, as also indicated by Reynar and Bruening (1996).

4. Conclusions

The limited participation of women in the process of delivery of extension advisory services restricts adoption of new technologies and sharing of information. Constraints are observed for all farmers at different levels, i.e. the institutional, technology-contextual, input access socio-cultural and extension level. Constraints encountered by women are sometimes gender specific. Empowerment in decision-making can hence create incentives to adopt better farming practices suggested under extension advisory services which integrate gender considerations. This is necessary, specifically, in the context where the male-centric extension services prohibit women from acquiring knowledge and skills. Such a gendered approach, for instance by employing women as trainers, can allow access to information by female farmers. This will result in greater productivity and efficiency gains and higher incomes. In addition, labour and time-reducing technologies enable women to enter into other profitable tasks.

However, it should be recognized that the adoption of some of these new labour-saving technologies could actually imply the need for additional operations to be conducted, albeit often at another stage of the cropping calendar. An example of such technology is the rotary weeder. The use of such weeders requires that transplanting is properly done in line, hence involves a higher labour demand at planting time in comparison with seed broadcast (Mujawamariya and Karema, 2017). Empowered women also learn to participate into technology design so that it responds to their needs.

In Ethiopia specifically, women are actively involved alongside men in many labour intensive agricultural activities. But their active participation does not result in recognition as farmers on equal footing with men due to the cultural misconception that women do not have time to fully engage in agricultural production. To address this misconception, research and development studies should focus on development of technologies that ease the workload of women and thus help female farmers to engage in productive agriculture.

In Tanzania, cultural impediments were identified. These are associated with the perceptions that it is wrong for a woman to be ‘seen’ working with a man. In such situations, training can be organized in groups rather than with individuals. Due to the women’s time allocation in different household activities, the framework for extension delivery can be tailored better to meet women's training needs by having flexible training schedules that are sensitive to women's workload. This will increase women’s attendance rates of agricultural extension training.

A more active participation of women and youth in the rice sector development process is noted in Madagascar. In the country, it is also important that the functioning of the agricultural extension services be reviewed for a better structure and for streamlining of

agricultural advice. Specifically, the existing information infrastructure and channels should be improved in terms of timely delivery of information and advice and provision of technical support.

Agricultural extension services are of paramount significance in improving the productivity of agriculture. In the three study countries, it appears that extension services need to be improved by addressing gender-based constraints and thereby enhancing positive impact among women producers and workers in rice hub related activities. To better reach women, the main entry points of innovation identified are: (1) increasing the number of agents to reach the farmers in general and women in particular, (2) promoting employment and training of women in agricultural extension services to better serve women farmers in areas where the socio-cultural context is characterized by gender inequalities. This can be achieved through attracting and maintaining women in agricultural science education and profession, (3) increasing the number of demonstration plots so that farmers can observe how the technology performs and are hence drawn to adoption. Demonstration should actively involve farmers as it enables them to gauge the risk involved, the inputs needed and the attainable results. This process allows them to make an informed decision with regard to adoption of new technologies (4) generating flexible training session schedules to enable women to complete their household tasks and participate in the training, (5) creating centralized and easily accessible communal spaces where extension services and farmer-to-farmer exchanges can be organized instead of distant locations, and (6) promoting extension services in developing curricula that are suitable for women instead of a generalized approach. In addition, group training sessions can be organized rather than an individual approach. The group training can significantly increase women's access to and the quality of these services without encroaching

on the cultural perceptions and norms.

These improvements and other related measures can increase gender equality and women empowerment in agriculture, which in turn will lead to sustainable productivity and profitability enhancements, income generation and poverty alleviation in SSA. For this to materialize and achieve impact, funding and efficiency aspects have to be addressed urgently.

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Appendix 1: Women Empowerment module

Who makes the decisions concerning each of the issues highlighted in the following table? *(DM refers to Decision Maker)*

1=Husband only
2=H>W, Husband dominates in decision-making process
3=Both husband and wife participate and take a joint decision
4=W>H (Wife dominates in decision-making)

5=Wife makes the decision

Item requiring decision-making	DM	Remarks	Item requiring decision-making	DM	Remarks
1. What rice variety to grow			**Expenditures on Production**		
2. Quantity of rice to use			19. When to spend earnings from sell of crops or livestock		
3. Variety distribution over plots			20. When to buy or hire farm implements for production		
Crop Management			21. Buying or hiring farm implement for harvest		
4. When to plant			22. Renting farm implements to other farmers		
5. Whether to apply fertilizer or other agro chemicals			23. How much income to transfer to other people such as children or elderly parents.		
6. When and where to buy fertilizers and pesticides from			**Livestock**		
7. When and how much fertilizer to apply			24. Number of animals to rear		
8. Whether to apply pesticide			25. When to sell or exchange animals for other benefits.		
9. When and how much pesticide to apply			26. Number of animals to rear		
10. When to weed			27. When to sell or exchange animals for other benefits.		
11. Whether to hire labour for farm operations			28. Investment Expenditure		
12. How many labourers we can hire and their gender			29. How much money to spend on food.		
13. When to harvest rice			30. Amount of expenditure on capital investment		
Post harvest operations			31. Whether or not to buy livestock		
14. Seed variety to be grown in the next cropping season			32. Whether to purchase land		
15. Amount of rice to sell or keep			33. House construction		
16. When to sell rice or other crops			34. Allocation of remittances		
17. Where and at what price to sell rice or other crops			**Politics**		
18. Whom to sell produce to			35. Who decides how you should cast your vote?		