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Women's prospects to adopt enhanced freshness formulation (EFF) technologies for banana in Morogoro rural district, Tanzania

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This paper draws lessons from a study based on forecasts rather than actual results. The study was conducted to identify factors that could potentially affect women's decisions to adopt enhanced freshness formulation (EFF) technologies among banana growers in Morogoro, Tanzania. The study tested whether men and women were equally likely to adopt EFF technologies. The authors also explored whether women who are willing and able to influence adoption decisions and women who are willing but unable to influence adoption decisions face similar adoption challenges. The results from logit model suggest that the adoption prospect is lower among female adopters than male adopters ($p < .05$). The study predicted a higher probability of female growers to be willing and able to influence adoption decisions among younger female growers compared to those over 35 years old ($p < .1$) although the overall impact on the adoption rate was low, owing to limited participation of young farmers (11 %) in banana production. The findings reveal less willingness and ability to adopt the technologies among female growers who perceived EFF applications as labour-insensitive technologies ($p < .05$). Likewise, the study identified higher willingness and ability to influence the adoption among growers whose bananas were not about to be harvested ($p < .05$). The authors recommend continued efforts to address a priori challenges that can potentially undermine adoption with easy-to-use preparation and application methods, and by targeting growers whose fruits are at early stages of maturation. Future studies could focus on the potential impacts of specific types of EFF technologies on the adoption prospect.

Keywords: Women, technology adoption, enhanced freshness formulation technologies, EFF technologies, shelf life, post-harvest loss, banana, fruit, Morogoro, Tanzania

Gender-based differences in the adoption of new technologies have long been recognized in farming communities. While there are varied and context-specific reasons for such differences, there is evidence that female farmers tend to adopt new agricultural technologies at a lower rate than male farmers (Doss 2001; Tiruneh et al. 2001; Bourdillon et al. 2002; Phiri et al. 2004; Kakooza et al. 2005; Jagger and Pender 2006; Thapa 2009; World Bank and IFPRI 2010; Peterman, Behrman, and Quisumbing 2010; FAO 2011). Consequently, there has been a growing interest to identify means to enhance the adoption of agricultural technology innovations amongst both male and female smallholder farmers. This interest has motivated the development of specific guidelines and user-tailored toolkits, such as a toolkit for gender-sensitive work in value chains (Farnworth 2011), that are used for streamlining gender-specific issues in agricultural development initiatives. These guidelines and toolkits are important references to guide current and future agricultural interventions but are based on specific case studies, experiences, and lessons that may not apply to all types of technologies and circumstances of potential adopters. To overcome gender-based barriers to technology adoption effectively, there is need for context-specific studies that examine how the adoption decisions are made and identify factors underlying the decision-making process.

Enhanced freshness formulation technologies are applications of nanotechnology that involve treating fruits with a natural compound – hexanal – that tends to slow down ripening and retain the freshness and nutrients of the fruits for a longer time. Such technologies are

considered vital for enhancing fruit quality and prolonging shelf life. These twin benefits can allow farmers to sell fruits in niche and high value markets and reduce post-harvest losses that are estimated to be as high as 30 % (Paliyath et al. 2009; Hailu, Workneh, and Belew 2014). These changes in quality and shelf life may also allow farmers to make more money from prolonged sales of fruits. Trials in Sri Lanka and India have shown the potential of EFF technologies in reducing post-harvest losses by extending the shelf life up to 21 days for mangoes and banana (Paliyath et al. 2009). It may be very beneficial for fruit growers in Tanzania to adopt EFF technologies. Technologies that prolong shelf life (i.e., quality-related benefits) will not only enhance the marketability of fruits but also likely provide economic gains for growers and other actors in the industry.

There is global evidence of the efficacy of the use of EFF technologies in addressing post-harvest freshness problems for apples, bananas, mangoes, and strawberries (Paliyath et al. 2009; De Kock and Taylor 2012). However, the full potential of EFF technologies to help the poor and support sustainable growth cannot be realized in Tanzania if the rate of adoption is lower for some groups of fruit growers than others. An understanding of gender dynamics in the adoption of these technologies is crucial for the discovery of complementary measures that can be adopted to improve package designs and to improve implementation strategies to ensure the desired development outcomes and impacts.

Adoption of enhanced freshness formulation technologies in Tanzania

The EFF technologies are currently being introduced in Tanzania for direct evaluation at farm level. It is likely that some of these technologies will be recommended for extension to growers of fruits such as bananas, mangoes, and oranges. However, no study has so far assessed the adoption prospect of these technologies from a gender perspective although gender differences tend to have different effects on men's and women's adoption of agricultural technologies (Doss and Morris 2001; Ogunlela and Mukhtar 2009; FAO 2011; Ndiritu, Kassie, and Shiferaw 2014). This understanding is important for promoters of these technologies to foresee real adoption challenges and identify *a priori* effective means for overcoming the challenges.

The existing literature reveals that women might be disadvantaged when making rapid adoption decisions where the technologies require specific knowledge and skills, because African women have relatively lower levels of education than men and may require longer time to learn about the technologies before they decide to adopt (Doss and Morris 2001; FAO 2011; Ndiritu, Kassie, and Shiferaw 2014). Also, experience has shown that efforts to mechanize agricultural operations tend to overlook women's needs and constraints (Carr and Hartl 2010; Ndiritu, Kassie, and Shiferaw 2014). These oversights normally lead to the generation of technologies that do not address women's concerns, thereby precluding their participation in the adoption process and eventual adoption. In the past, promoters of new technologies often did not account for these potential (i.e., gender) differences during the design and promotion phase.

Overall, what matters for potential adopters of the EFF technologies in Tanzania, is whether they perceive the technologies to be relevant. In typical farming communities, farmers encountering unique problems may decide against adopting the technologies (Satyavathi, Bharadwaj, and Brahmanand 2010; Doss 2001). Understanding all, or at least many or most of these adoption challenges is crucial to informing a programme seeking to promote the adoption and commercialization of the technologies in Tanzania. This understanding is vital for ensuring that gender issues are considered in the design and promotion of agricultural interventions and research for development.

Decision to adopt agricultural technology

The actual adoption and use of any new agricultural technology is primarily determined by farmers' decisions to adopt it. Historically this decision appears to be biased along gender lines. The authors wish to establish whether men and women stand equal chances of adopting EFF technologies and under what circumstances.

The literature shows that there are differences in men's and women's decisions to adopt and use agricultural technologies. One of the fundamental differences is with respect to their risk attitude (FAO 2011) and access to knowledge, critical support services and agricultural assets; and men tend to have a competitive edge over women (Ndiritu, Kassie, and Shiferaw 2014). Moreover, women are more liable to perform both household chores and agricultural activities, which reduces their time available to learn about new technologies (Ogunlela and Mukhtar 2009; Meinzen-Dick et al. 2010; Satyavathi, Bharadwaj, and Brahmanand 2010). These factors can potentially limit women's adoption of both labour- and capital-intensive agricultural technologies (Satyavathi, Bharadwaj, and Brahmanand 2010; Doss 2001). The differential impacts of these factors on men's and women's decisions to adopt and use agricultural technologies have been widely studied and are well documented. Much is based on the assumption that members of households pool resources and make joint decisions (Ndiritu, Kassie, and Shiferaw 2014). However, men and women are expected to make different decisions owing to power imbalances and inequalities that exist within households and between men and women (FAO 2011; World Bank and IFPRI 2010). The belief that households pool resources and make joint decisions could tempt researchers to target heads of households as interviewees during surveys (FAO 2011; World Bank and IFPRI 2010) leading to biased information, because women's opinions may not be adequately captured. Thus, new ways are needed to account for both men's and women's decision-making at the household level. The potential bias could be reduced through solicitation of detailed information that describes power dynamics and pinpoints factors that can make some family members more likely to adopt new technologies than others.

In view of this focus, leadership and decision-making within a household should be treated as separate aspects of data collection and analysis because the head of a household may not necessarily be the main decision maker. This separation allows for examination of the decision-making processes in both female- and male-headed households and is the approach that the authors adopted to examine whether men and women are equally likely to adopt EFF technologies and to identify specific factors underlying the adoption prospect among female adopters. Studies that have solely assessed differences in the adoption of agricultural technologies among female adopters have been rare.

Technology adoption theory

The adoption of EFF technologies is likely to follow the theory of five stages of technology adoption (Yoh et al. 2003; Rogers et al. 2005). The theory suggests that awareness creation is the first stage of technology adoption. However, men and women in the same household are likely to be differentially aware as they are likely to be linked to different social networks (Gotschi, Njuki and Delve 2008; FAO 2011; Kassie et al. 2013; Di Falco and Bulte 2011; Pandolfelli, Meinzen-Dick and Dohrn 2008; Doss et al. 2003). Consequently, their perceptions of the cost and benefits associated with the adoption and use of new agricultural technologies are likely to be different.

Men's and women's desires to adopt agricultural technologies are likely to be

influenced by several factors including differences in access to and control over resources such as land, other assets, and financial resources (Bryant and Pini 2006; Doss and Morris 2001; Doss 2002); and socio-economic characteristics and other household-specific dynamics such as power relations and social and family obligations (Haque et al. 2010; FAO 2011). The roles and responsibilities they assume in farming and at the household level have important ramifications for their decisions to adopt agricultural technologies. In households where men are more powerful than women, the ability of female members to influence decisions is normally restricted. Moreover, if women are liable to perform both family and agricultural activities, they are less likely to have time to learn about new technologies. Consequently, they will be less informed about the technologies and disadvantaged in the adoption of the technologies (Doss 2001).

Preferences for crops have also been reported to affect the adoption of agricultural technologies. In many agrarian communities in Africa, women tend to disassociate themselves from decisions that lead to adoption of technologies that will affect the production of cash crops alone. In these communities, cash crops are perceived to be men's crops. Women are instead interested in crops that ensure steady supplies of food for family members and in the shelf life of these crops (Badstue 2006; Bellon et al. 2003).

Overall, there are several factors that can potentially affect men's and women's decisions differently. The EFF technologies are relatively complex technologies and new to potential adopters in Tanzania. In view of the fundamental differences in men's and women's decision-making approaches, it is reasonable to expect that there will be some differences in their preferences to adopt the technologies. It is important to assess the factors hypothesized to influence the adoption of agricultural technologies in the study area.

Conceptual framework of the study

The authors perceive the decision to adopt agricultural technologies to be an inherently complex process that is primarily under the influence of social and cultural factors that define norms and affect men and women differently (van Eerdewijk and Danielsen 2015). When the norms subject women to more social obligations such as farm and family caretaking, their burdens will be great with little time for accessing critical information on agricultural production and business development. In Tanzania, for example, social and cultural factors normally force women to allocate more time for farm and family obligations than men do (Meeker and Meekers 1997). This difference in men's and women's roles may indirectly undermine women's access to agricultural support services as there could also be preferential targeting in favour of household heads who, in many African societies, are men. Moreover, the norms could also be against women's independence and voicing of concerns. The combined effect of these cultural hindrances undermines women's demand for, and their adoption of, agricultural technologies. If the norms also allow men to have better access to and greater control over resources than women, women will have limited ownership of resources and less control over the resources and income. The ultimate effect is to reduce women's prospects of adopting the technologies as depicted in Figure 1. The severity of effects of norms that are against women's independence and voicing of concerns is also likely to vary among women as they have different levels of exposure to resources, as well as knowledge of and skills in agricultural technologies.

The research conducted and hence this paper, hinges on the conceptual framework discussed under this section to statistically assess differences in the adoption prospects of EFF technologies between men and women, and among women. The paper focuses on

identifying factors that can potentially affect women's decisions to adopt EFF technologies in Tanzania and it contributes to the adoption literature in three ways: In terms of analytical methods, it proposes a better way to analyse sex disaggregated data for technology adoption and diffusion. In terms of empirical evidence, it establishes whether men and women are equally likely to adopt the EFF technologies and it explores further, whether women who are willing and able to influence adoption decisions, face similar adoption challenges to those who are willing but unable to influence the decisions.

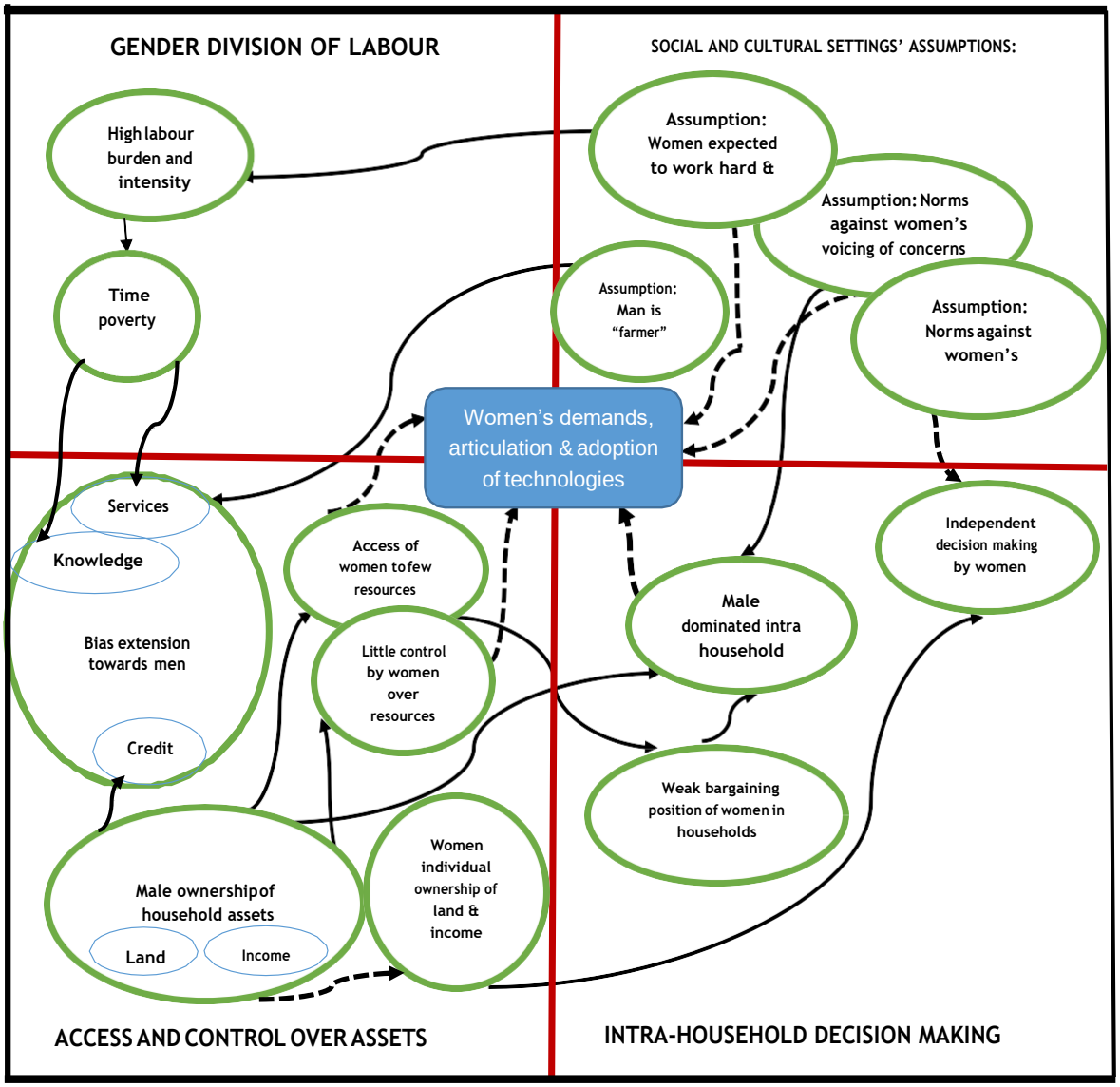

Figure 1: Gender perspective on effects of norms and other cultural factors on the adoption of technology.

Note: The above figure shows causes and effects of norms that tend to be against women's voicing of concerns and ownership of resources, and that disproportionately subject women to more obligations. It portrays the conceptual framework adopted to assess differences in the adoption prospects of EFF technologies in study areas. Dashed arrows represent inhibitory or negative effects while solid arrows represent potentiating or positive effects.
Source: Adapted from van Eerdewijk and Danielsen (2015).

Materials and methods

Frequencies and mean values which were computed using STATA (version 12) are some of the statistics used to describe farmers' opinions about adopting the EFF technologies. The authors measured both farmers' willingness to adopt and their perceived ability to influence the ultimate adoption decision. These and other variables that are presented in subsequent sections were collected during a survey that was conducted in banana growing areas using a pretested questionnaire. Farmer's willingness to adopt EFF technologies was assessed through a binary response variable (coded one if a farmer was willing to adopt the technologies and zero, otherwise). The assessment was done after awareness creation with respect to cost of adoption and potential benefits of EFF technologies. Also respondents were asked whether they were the main decision makers, i.e., were able to influence decisions to adopt the EFF technologies. These two variables were then used to construct a surrogate variable that measured whether a particular respondent was willing to adopt the technologies and able to influence the adoption decision and is one of the key variables that was analysed. It is worth noting that this surrogate variable was measured on the basis of respondents' "stated" willingness to adopt the technologies and their ability to influence adoption decisions when the technologies become available in the market. Thus, in subsequent sections, the term perception is used to mean farmers' own assessment of technology adoption prospect and their perceived ability to influence such decisions.

A z-test that is similar to the single-group *t*-test, popularly known as the *z*-test for the difference between two proportions, was adopted to test whether there was no difference between men's and women's prospects of adopting EFF technologies in two banana growing areas within Morogoro region. The proportions are aggregate measures (point estimates) of men's and women's willingness to adopt the technologies and their ability to influence the adoption decisions. Thus, the application of this test is not based on the normality assumption because respondents that were willing to adopt the technologies but unable to influence the adoption decisions were not considered in this analysis. The null hypothesis assumed equal proportions of male and female adopters. The test statistic was computed as:

$$z = \frac{p - \pi}{\sqrt{\frac{\pi(1-\pi)}{n}}} \quad \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

In equation (1), p is the proportion of women that was willing to adopt the technologies and able to influence the adoption decisions, π is the null hypothesis value signifying the expected proportion if there is no difference between the proportions of men and women with such attributes, and n is the sample size.

The study also tested whether there were differences between men's and women's perception of labour intensity of the EFF technologies. This analysis was motivated by the fact that there could be differences between men's and women's prospects of adopting EFF technologies attributable to their perception of the labour intensity of the technologies as it has already been established that Tanzanian women dislike technologies that increase their labour burden (Meeker and Meekers 1997). The test was performed using the Mann-Whitney U which is a non-parametric test used to determine if the independent groups (men vis-à-vis women) differ significantly from each other with respect to perception of labour intensity of the EFF technologies.

The test allows two groups or conditions or treatments to be compared without making the assumption that values are normally distributed. The test requires the samples to be

independent and random and the variables being compared to be measured as continuous units and the scale used to be at least ordinal. The logic behind this test is that when the samples differ, the distributions of the two populations will differ only with respect to the central location. If the sum of rankings from one sample differs enough from the sum of rankings from the other sample, the conclusion is that there is a difference in the population medians (Kasuya 2001). The test statistic is computed as:

$$U_1 = n_1 n_2 + \frac{n_1(n_1+1)}{2} - \sum R_1$$

$$U_2 = n_1 n_2 + \frac{n_2(n_2+1)}{2} - \sum R_2 \quad \text{..... (2)}$$

where:

n_1 and n_2 are the sample sizes for male men and women, respectively; and

$\sum R_1$ and $\sum R_2$ = Sum of ranks for samples 1 and 2, respectively.

Moreover, the study also tested whether there was no difference in willingness and ability to adopt the technologies between female adopters on the basis of observable characteristics of adopters. The difference was tested using the conventional random utility model for binary choices (Ali and Abdulai 2010; Becerril and Abdulai 2010). The chosen model was fitted as a logit to associate the categories of female adopters (y) with specific, independent variables (x). The null hypothesis assumed no difference in willingness and ability to influence adoption decisions between female adopters. The analytical model was specified as:

$$\text{Prob}(y = 1 \mid x) = \Lambda(x\beta) = \frac{\exp(x\beta)}{1 + \exp(x\beta)} \quad \text{..... (3)}$$

In equation (3), Λ stands for the cumulative distribution function of the logistic distribution while x and β are vectors of independent variables and parameters to be estimated, respectively.

In the logit model the dependent variable is an indicator of whether a woman in a particular household was willing to adopt and able to influence the decision to adopt EFF technologies (Table 1). Independent variables included in the model were those identified in contemporary literature to influence farmers' decisions to adopt agricultural technologies (Gabre-Madhin and Haggblade 2001; Ouma et al. 2002; Reardon, Stamoulis and Pingali 2007). Independent variables included both socio-economic characteristics of farmers along with those measuring farmers' perceptions of the EFF technologies (Table 1). Farmers' perceptions of the labour intensity of the EFF technologies were believed to be important, particularly for female farmers. According to previous research, women tend to disassociate from decisions leading to the adoption of labour-intensive technologies as their workload is normally already heavy (Berti, Krasevec and FitzGerald 2004). Farmers' ages were included as a measure of potential differences in risk attitudes and experiences. The literature reveals that when risk aversion predominates, older farmers might be less willing to adopt new technologies than younger farmers (Alexander and Van Mellor 2005).

Table 1: Factors influencing farmers' decision-making for adopting EFF technologies

Variable	Description	Expected sign
Y_i = Adopter category	Coded as 1 if the main decision maker was a woman and willing to adopt EFF technologies; 0 if she was willing to adopt the technologies but unable to influence adoption decision.	
X_1 = Age category	Coded as 1 if the age of the main decision maker was above 35 years; 0 otherwise.	+/-
X_2 = Income share	Coded as 1 if household share of income from agriculture was greater than 60 %; 0 otherwise.	+
X_3 = Fruit status	Coded as 1 if fruits were about to be harvested; 0 otherwise.	-
X_4 = Savings	Coded as 1 if the decision maker saved money; 0 otherwise.	+
X_5 = Labour intensity	Coded as 1 if the technology was perceived to be labour intensive, 0 otherwise.	-
X_6 = Fruit production	Coded as 1 if the main decision maker was experienced in fruit production; 0 otherwise.	+
X_7 = School-aged kids	Coded as 1 if the main decision maker had school-age kids; 0 otherwise.	+
X_8 = Plot owned	Amount of plot owned in acreage.	+

The status of the farmed fruit was included as one of the variables. It was expected that fruit growers would be more willing to adopt the EFF technologies when time-to-maturity allowed them to both improve fruit quality (i.e., increase value) and prolong the harvesting period so as to hedge against price risk. Saving behaviour was included as a measure of a farmer's ability to finance the adoption of the technologies and was expected to have a positive effect on the adoption decision. The share of income derived from agriculture was considered as an appropriate measure of the lucrativeness of the farming business and was expected to have a positive effect on the decision to adopt EFF technologies. Having school-age kids was included as a measure of the parents' social obligation. It was expected that females with school-age kids would be particularly hesitant to adopt capital- and labour-intensive technologies as they attempt to save time and resources for their kids. Plot ownership was included as a measure of farmers' resource bases for agricultural production and was believed to be positively associated with the decision to adopt agricultural technologies.

The model was estimated using data that were collected by the authors in 2015 from a random sample of 96 banana growers. The respondents were proportionately drawn from two banana-growing areas in Morogoro, a rural district of Tanzania, based on the actual number of growers in each area. The banana growing areas that were selected, were those where the EFF project was implemented. During the interview, respondents were randomly selected from a list of banana growers obtained from extension officers working in the project areas. In addition to the variables described in preceding sections, the survey also solicited information on other aspects of banana farming including farmers' socio-economic and demographic characteristics, their levels of involvement in planning and performing different activities, and access to and control over assets and other resources at the household level. During the analysis, the data were not disaggregated by study areas to retain the sample size and enhance robustness of parameters that were estimated using the maximum likelihood method.

Results

Results demonstrated that the proportion of men and women who appeared to be willing and able to adopt the EFF technologies was different (z = -1.97, p < .01). Overall there were more men than women who appeared willing and able to influence the adoption decision (z =-1.86, p < .01). Also, the proportion of female farmers (mean rank = 63.75) that perceived EFF technologies as labour intensive technology was significantly higher (z = -3.352, p< .05) than the proportion of men with that perception (mean rank = 43.80).

Results from the descriptive analysis revealed that most of the female banana growers who were willing and able to influence the decision to adopt EFF technologies along with those who were willing but unable to influence the decisions were over 35 years old, more able to save money, and did not perceive EFF as labour-intensive technologies (Table 2). Also, a relatively large number of these decision-makers were those whose bananas were about to be harvested, had a share of income from agriculture above 60%, but were less experienced in banana production.

Overall, the proportions presented in Table 2 suggest that women who were willing and able to influence decisions to adopt the EFF technologies might share similar characteristics. This assumption was tested using parameters generated from the logit model and the results are presented in Table 3.

Table 3 reveals age (p<.1), perception of labour intensity (p<.05) of the EFF technologies, and status of banana fruit (p < .05) as variables that affect the likelihood of female growers to be willing and able to make the adoption decision. The odds of influencing the adoption decision were estimated to be 0.77 lower among farmers who were above 35 years than those below this age. Similarly, the odds of influencing such a decision were estimated to decrease by 0.75 when a female decision-maker perceived EFF as labour-intensive technologies, and to decrease by 0.82 when the decision-maker had banana fruits that were being harvested.

Table 2: Number of women (proportion or mean) for nine survey variables collected in 2015 in two locations in Morogoro rural district, Tanzania

Variables		**Number of women (proportion or mean)**	
		Willing and able to influence adoption decision	**Willing but not able to influence adoption decision**
Adopter category		4 (58 %)	6 (42 %)
Age category	< 35 years	50 (4.2 %)	35 (6.3 %)
	≥ 35 years	11 (52.7 %)	10 (36.8 %)
Income share	< 60 %	43 (11.6 %)	31 (10.5 %)
	≥ 60 %	15 (45.3 %)	5 (32.6 %)
Fruit status	About to be harvested	39 (15.8 %)	36 (5.3 %)
	Not about to be harvested	23 (41.0 %)	20 (37.9 %)
Savings	No	31 (24.2 %)	21 (21.1 %)
	Yes	47 (32.6 %)	32 (22.1 %)
Labour intensity	No	(50.5 %)	(33.7 %)
	Yes	6 (6.3 %)	9 (9.5 %)
Fruit production experience	No	32 (33.7 %)	28 (29.5 %)
	Yes	22 (23.1 %)	13 (13.7 %)
School-age kids	Mean	53 (2.3)	41 (2.0)
Plot owned acreage)	Mean	53 (1.03)	41 (0.8)

Table 3: Regression coefficients, standard errors, Z-values, p-values and 95 % confidence intervals of the logit model fitted to assess willingness to adopt the EFF technologies in two locations in Morogoro rural district, Tanzania

Variable	Odds Ratio	Standard Error	Z	P>|z|	95 % Confidence Interval	
Constant	2.65	2.61	0.99	0.32	0.38	18.20
Age category	0.23	0.19	-1.80	0.07	0.05	1.13
Income share	1.32	0.75	0.49	0.62	0.43	4.04
Fruit status	0.25	0.17	-2.06	0.04	0.07	0.94
Savings	1.82	0.93	1.18	0.24	0.67	4.96
Labour intensity	0.18	1.31	-2.37	0.02	0.45	0.75
Fruit production experience	2.17	1.17	1.43	0.15	0.75	6.26
School aged kids	1.01	0.08	0.07	0.96	0.86	1.16
Plot owned	1.08	0.18	0.49	0.63	0.78	1.49

Note: Number of observations =91; $chi^2 = 13.68$; prob. > $chi^2 = 0.0492$;
log pseudo likelihood = 0.1106

Discussion

The implication of the results is that female growers in the study area who were young (i.e., < 35 years) and willing and able to influence the adoption decisions, were more likely to adopt the EFF technologies than older growers with similar characteristics. However, the proportion of young, female farmers in the study areas was small (10.5 %) implying less impact on the overall adoption rate.

The findings also revealed a low probability to be willing and able to influence the adoption decision among females who perceived EFF as labour-intensive technologies. About 16 % of the decision makers felt that the technologies were labour-intensive. Furthermore, the findings suggest that decision-makers whose fruits were just about to be harvested were less likely to adopt the EFF technologies than those whose fruits were at earlier stages of maturation. Time-to-fruit maturity served as a proxy for time available for decision-makers to adopt the practice and allow the realization of sufficient gains and benefits. The adoption of EFF technologies when fruits were maturing might not accord growers sufficient time to reap benefits through prolonged sales. According to the descriptive statistics presented in Table 2, a majority of the decision-makers (78.9 %) who were willing to adopt the technologies were those whose fruits were not about to be harvested.

The findings of this study affirmed the general view that men are more likely to adopt new agricultural technologies than women and are consistent with findings from other studies conducted in Sub-Saharan Africa (Doss 2001; Ndiritu, Kassie and Shiferaw 2014). Using the Mann-whitney U test, the analysis identified that poor access to support services, especially financial services (z=-3.467, $p < .05$), and lack of relevant knowledge and experience (z=3.371, $p < .05$) were the main reasons to justify the observed difference in the study area. Also, the finding of higher adoption prospects among farmers whose banana trees are at early stages of maturation implies that selective treatment of the banana fruits with EFF formulations at this stage could delay fruit maturity, thereby prolonging the sale of fruits and hedging bets against the low prices that are normally offered when the supply is high.

This study found higher adoption prospects of EFF technologies among young farmers,

especially females but the proportion of these farmers in the study area was negligible (about 11%). Previous research by others found higher adoption prospects among this group of farmers and associated the higher adoption rate with their willingness to try new things and their greater ability to learn and acquire new skills (Alexander and Van Mellor 2005). Our study predicted a lower adoption rate among female farmers perceiving EFF technologies as labour intensive which implies that easing the formulation and application of the EFF technologies can potentially make the technologies more appealing to female growers and accelerate adoption.

With respect to labour intensity of the technologies, female growers in the study area were accustomed to agricultural technologies involving the use of labour-intensive equipment such as knapsack sprayers that are widely used to spray agro-chemicals. This experience might have caused them to perceive the EFF technologies to be similar to other labour-intensive technologies that exist in their communities. Previous studies have also established that women are less likely to adopt technologies that raise their total labour burden and intensity (Berti, Krasevec and FitzGerald 2004; Doss 2001).

The authors acknowledge that there could be potential confounding with location (i.e., data arose from two locations) as we did not control for location in our statistical analysis. The potential impact of this is unknown and is worth exploring in future studies.

Conclusion and recommendations

The study found that the adoption prospect for EFF technologies is lower among female farmers than male farmers. This calls for continued efforts to address a priori challenges that can potentially undermine adoption, especially unequal access to agricultural support services and knowledge.

The study also found a higher adoption prospect among growers whose bananas were not about to be harvested, so efforts to promote the adoption of these technologies among new users should primarily focus on growers when fruits are in early stages of maturation. Future studies could focus on impacts of specific formulations of EFF technologies on the adoption prospect.

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