Food Chain, 7:1, 38–54
<http://dx.doi.org/10.3362/2046-1887.17-00005>

Does women's agency influence agriculture technology adoption?

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Abstract: *This paper assesses women's agency and its influence on technology adoption in agriculture. In undertaking the study, data was sourced from CARE Pathways Programme 2013 Annual Review Studies in Tanzania and Malawi. The cohort technique was used to select a sample of 149 female respondents from both female- and male-headed households. Using a probit regression model, the study found a significant and positive relationship between high agency and knowledge on gender issues, positive perception of gender roles, and farm size. In contrast, access to a broad range of information sources and belonging to female-headed households enhance the likelihood of low agency. Using the OLS regression model, the study reveals a positive and significant relationship between women's agency and adoption of production technologies. This implies that interventions to enhance adoption of agricultural technologies among rural women must aim at building their capabilities to take purposeful actions.*

Keywords: women's agency, women's empowerment, gender, technology adoption, agriculture

Introduction

The role of technology in agricultural productivity has been widely studied. Technology has been proven to enhance agricultural productivity and profitability and reduce household poverty (Asfaw et al., 2012; Gitonga et al., 2013). Agricultural technologies are broadly defined as improved practices, inputs, crop varieties, and other products used to increase agricultural productivity and improve livelihoods (Jack and Tobias, 2017).

However, several studies have established gender inequalities in the adoption of technologies for agricultural production (Peterman et al., 2010; Ragasa, 2012). Generally, women farmers have been shown to have relatively low rates of adoption of agricultural technologies (Peterman et al., 2010). This is despite the fact that women constitute the majority of small-scale farmers in rural settings where about 79 per cent of them have agriculture as their primary form of occupation (Doss, 2014). The low adoption of agricultural technology by women farmers has been attributed to the constraints faced by women in agriculture. These include low income and lack of access to resources such as credit and labour, as well as lack of access to extension services (Ellis et al., 2007; FAO, 2011; SOFA and Doss, 2011).

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However, Bonnard and Scherr (1994) argue that addressing gender issues during technology design and implementation will not entirely solve the problem of technology adoption. This is due to the fact that societal rules and norms and household decision-making problems are tilted towards male concerns; hence, it becomes difficult to predict gender-related outcomes of technology development. The solutions have to start from the process of decision-making; women have to be in control of decisions on issues that affect their lives (FAO, 2011). This is because roles and responsibilities in agricultural production are often gendered, with men and women performing different roles along the value chain. Similarly, studies have shown that pathways for accessing and acquiring assets and other productive resources, including technology, are also gendered (Meinzen-Dick et al., 2011). However, studies and policies often neglect this, reflecting a masculine, one-sided viewpoint of agricultural tasks and production. Most agricultural researchers do not give attention to gender analysis in technology development. This lack of gender sensitivity affects technology adoption and the benefits that could be derived by both men and women.

It is therefore important to consider women's ability to make independent decisions and the influence on agricultural technology adoption. Regarded as 'agency', this study therefore argues that the ability and freedom to make decisions about issues important to women goes a long way in determining the extent to which technologies are adopted for their agricultural activities. This is because autonomy in decision-making is an important factor in assessing empowerment. As defined by Sen (1999), agency is a person's ability to act on behalf of things they value and have reason to value. This means the ability of individuals to make their own free choices (Luttrell et al., 2009) or the individual's ability to make choices that are important to defining his or her own interests, projects, and goals (Nussbaum, 2011). This means that people may need to be self-confident and self-determined, to know what they want, and to direct their actions towards that goal without being coerced, manipulated, or forced (Samman and Santos, 2009). It also includes the motivation and purpose which individuals bring to their actions (Kabeer, 1999).

There is the need to differentiate between agency and empowerment. Agency itself is not synonymous with empowerment but it is an important determinant (Alsop et al., 2006). According to Kabeer (1999), individual capacity to effectively make choices may be constrained by institutional context within which actors operate. This may limit their ability to transform agency into action. Hence, for a person to be empowered, he or she must not only have the autonomy in decision-making on issues he or she values (agency) but also the resources needed to translate the choice into actions or desirable outcomes (Kabeer, 1999; Alsop et al., 2006). This study therefore focusses on women's agency by measuring their convictions in the different spheres of their lives.

In measuring agency, certain proxies including social capital indicators like education and skills as well as asset indicators like ownership of assets and income are used. These indicators provide an inadequate measure of agency because they neglect the measure of autonomy of women to make choices on issues that concern them about technologies in agriculture (Alkire, 2007).

Also, since agency is multi-dimensional, Alkire et al. (2013) argue that measures of women's agency in agriculture should focus on different spheres of life. In other words, measures of agency should be domain-specific. This is important for policy because it provides a holistic understanding of the context of rural women, in which decisions in one area are intertwined with others; hence, it is important to identify and compare agency achievements in different domains rather than in one alone (Alkire, 2007). This influences the construct of agency in this study. It focusses on women's 'power within' to make purposeful choices on different spheres of their lives.

In assessing the agency of the women farmers, this study examines women's autonomy in different spheres of life such as access to resources, community activity, decision-making on agricultural activity, household decisions, and personal decisions on life's major issues. Specifically, the main objectives of the study are twofold:

1. Examine the different factors influencing women's agency in the study area.
2. Assess the influence of women's agency on agricultural technology adoption.

Methodology

Description of the study area

This study uses the data collected in two of the CARE Pathways countries, Tanzania and Malawi. CARE Pathways (Women in Agriculture) Programme is funded by the Bill & Melinda Gates Foundation with the aim of improving poor smallholder women farmer's productivity and profitability by empowering them to fully participate in equitable agricultural systems (CARE Pathways, 2017). The programme is implemented in Ghana, Malawi, Bangladesh, India, Mali, and Tanzania. In order to increase smallholder women's productivity and profitability, Pathways uses the Farmer Field and Business School (FFBS), an upgrade over the traditional Farmer Field School (FFS) approach. The FFBS is a learning-by-doing approach through which groups of farmers meet regularly in the course of cropping or livestock production cycles to experiment and learn about new production and marketing options. The FFBS uses community approaches to integrate visioning and planning, sustainable agriculture, market engagement, nutrition, gender, and performance monitoring.

The Tanzania Pathways project is implemented in the districts of Masasi and Nachingwea in Mtwara and Lindi regions of southern Tanzania, some of the least-developed districts in the country. The project targets 8,500 women in poor smallholder households and women who are heads of households involved in sesame and cassava value chain activities. In Malawi, the Pathways project is implemented in two rural central districts, Dowa and Kasungu, covering four Traditional Authorities. These respondents are mainly smallholder farmers involved in the soya and groundnut value chain. The project works with 12,000 poor women and plans to directly impact 48,000 people throughout the five-year project implementation.

Women in Africa are traditionally the pillar of food security and nutrition, making sure that their families have enough to eat even when times are tough and harvests fail. In Malawi, women produce different types of crops such as beans, groundnuts, millet, and sorghum which could be sold for profit and provide an excellent source of nutrition and income (UN Women, 2016). In Tanzania, the major crops cultivated included sesame and cassava, while soya and groundnut were the main crops in Malawi. Access to land among smallholders for agricultural purposes is either through inheritance, buying, or renting. Due to credit constraints, most smallholders, especially women, rely on community land or renting for agricultural purposes. While in many African communities, inheritance is patrilineal, in the Mtwara district of Tanzania, one of the rural districts where this study was conducted, and generally in Malawi, inheritance is matrilineal; that is, the line of descent is traced through the mother's lineage and can be used to determine inheritance of land and other assets (Forsythe et al., 2016). Despite this, major decisions on agricultural activities are controlled by maternal uncles. This, in addition to lack of credit or collateral to either purchase or rent land, limits participation of rural women in agricultural production (Hirschmann and Vaughan, 1983; Rose, 2002; Shayo and Martin, 2009).

Data and sampling

The data was collected using a quantitative survey tool that was administered to an adult female in both female- and male-headed households, with a separate shorter survey administered to the adult male in the male-headed household. In undertaking this study, data from the CARE Pathways Programme 2013 Annual Review Studies (ARS) in Tanzania and Malawi were used (CARE US, 2013). Using a cohort technique, between 8 and 10 per cent of the households who took part in the baseline survey were sampled for each country in the ARS. In Tanzania, 849 households were sampled in the baseline survey. From this, 85 households, which constitute 10 per cent of the baseline sample, were randomly selected for the study. The 85 households were from seven villages in Masasi district and nine villages in Nachingwea district. A total of 78 questionnaires, representing about 92 per cent response rate, were retrieved from the survey in Tanzania. A similar process was used for Malawi, where 763 households participated in the baseline study. From this, 74 households, which constitute 9.7 per cent of the baseline sample, were randomly selected for the study; 71 questionnaires were retrieved representing 95.9 per cent response rate. Data from the two countries were merged to obtain 149 questionnaires on which the analysis for this study was undertaken.

The ARS captured information from a number of domains with primary focus on the performance indicators that align with the Pathways Theory of Change. These domains are women's self-confidence, access to inputs and services, agricultural production and productivity, use of improved practices, improved income, income and asset management, women and decision-making, and perceptions and changes of household gender roles, including men's engagement and women's mobility. Data on technology adoption was collected with a focus on two main

types of technologies: production and processing technologies. 'Technology' in this study refers to inputs, tools, techniques, sustainable agriculture practices, or innovation that could increase quality and quantity of products to meet both the food and market needs of the household. Technologies covered in this study are those relevant and paramount to the productive activities of the respondents, especially in regard to the main crops produced in the area: sesame, cassava, groundnut, and soya. Production technologies are specifically those technologies, techniques, practices, and innovations that have been introduced to the respondents in the course of their participation in the CARE Pathways Programme. These include proper land selection techniques, minimum tillage practices, use of soil erosion control methods, use of certified seeds, use of intercropping, cover crops and mulching, and weeding techniques. Processing technologies are tools and techniques used for the transformation of crops or produce to reduce post-harvest losses, preserve, crop lifespan, or repackage produce for better consumption or market value. These include tools and techniques that have been introduced under the CARE Pathways Programme such as drying, shelling, sorting, grading, packaging, and storage.

Dependent and independent variables

In the context of this study, agency assesses the conviction of women about their 'power-within' to make choices on issues they value. Thus, we introduce the variable W_CONVICT as a proxy for agency. This is constructed from five questions on a 5-scale Likert, each assessing respondents' confidence and ability to make choices on issues that are important to their lives (Table 4). The scale includes strongly agree, agree, strongly disagree, somewhat disagree, and indifferent. Respondents who choose either 'strongly agree' or 'agree' in each of the five questions are assigned a score of 1, otherwise, the respondent is assigned 0. A dummy variable is thus created, with those who have a total score of a minimum of 4 said to have a high agency, otherwise, low. In order to measure technology adoption among women smallholders, two dummy variables were constructed as dependent variables. The first variable indicates the number of production technologies a smallholder adopts in their agricultural activities in the last 12 months (T_PROD). The second variable, adoption of post-harvest technologies (T_PROC), is constructed in a similar way. The definition of variables as used in the regression analyses is shown in Table 1.

To answer the first objective, some explanatory variables were included in a probit model to assess the determinants of women's agency. These include women's gender roles and perception (G_PERCEPTION), measured by women's perception on issues such as household decisions, domestic chores, time and workload, family planning, and domestic violence, and women's knowledge of gender issues (G_KNOWLEDGE). Another is control over decision-making processes on income from sale of agricultural produce (P_INCOME) and their marital status (M_STATUS). These are expected to positively influence women's agency. The study also considered some external variables such as sources of information (S_INFORMATION), sources of market, and market strategies and sources of training (S_TRAINING). These are largely outside the control of farmers but can greatly enhance their agency by assisting women farmers

Table 1 Definition of variables

Variable name	*Definition of variables*	*Variable type*
T_PROD	Number of production technologies adopted	Integer
T_PROC	Number of processing technologies adopted	Integer
W_CONVICT	Women's agency (Have conviction = 1; No conviction = 0)	Dummy
F_SECURE	Number of months in a year with adequate food (months)	Integer
G_PERCEPTION	Positive perception of gender roles and decision-making	Ordinal
G_KNOWLEDGE	Knowledge of gender issues	Ordinal
S_INFORMATION	Information sources used by respondents	Ordinal
S_TRAINING	Training sources used by respondents	Ordinal
MARKET_STR	Market strategies adopted by respondents	Ordinal
P_INCOME	Power over spending of income from agriculture (Have power = 1; No power = 0)	Dummy
HH_TYPE	Headship of households (male-headed = 0; female-headed = 1)	Dummy
M_STATUS	Marital status of respondents (Single = 1; Married = 2; Separated = 3; Divorced = 4; Widowed = 5)	Nominal
LAND	Total land area cultivated (acres)	Continuous
M_VSLA	Membership of VSLA (Yes = 1; No = 0)	Dummy
M_PRODUCER	Membership of producer group (Yes = 1; No = 0)	Dummy
SAVINGS	Have savings from agricultural income (Yes = 1; No = 0)	Dummy

in making informed decisions. For example, S_INFORMATION is defined as different sources of information available to farmers to enhance their capacity to make decisions on technology adoption. The sources include farmer to farmer, government extension agents, traders, agro-dealers, radio, television, NGOs, demonstration plots, other farmers, and cooperatives. Similarly, the different market strategies (MARKET_STR) used by farmers are expected to positively influence farmers' decision-making in adopting a particular technology. The market sources considered under the programme include spouse, producer group, other producers, other farmers, village agents, cell phones or SMS update, radio, television, government extension agents, traders, input suppliers or agro-dealers, and NGOs. Market strategies include 'setting sales price based on calculating the cost of production', 'setting sales price based on market information source', 'bulk sale through farmers' groups', and 'bulk transport through farmers' groups'. Other exogenous variables in the study include food security (F_SECURE). This measures the adequacy of a farmer in food sufficiency throughout the year. Women who are food secured and have access to funds are expected to be able to make the right choices regarding the adoption of technologies. These allow women to exercise freedom to make choices they value without coercion or due to lack of options. Similarly, the study considered the influence of some demographic variables on women's agency. These include household type (HH_TYPE), land areas cultivated for agricultural purposes (LAND), and membership of a collective such as Village Savings and Loan Associations (VSLAs) (M_VSLA), and producer groups

(M_PRODUCER). While household type, measured by the headship of the household, is usually used to depict who controls decision-making on agricultural inputs, produce, and income, land is usually a measure of wealth of the household (Boucher et al., 2008). The bigger the land used in cultivation, the higher the likelihood of adopting agricultural technologies. The final variable used in the analysis is savings from agricultural income (SAVINGS). This is important for agricultural activities in rural areas where there is a lack of cheap and accessible credit facilities; hence, savings from sales from previous agricultural produce serve as a source of funds for investment in agricultural activities in subsequent years.

In answering the second objective, two OLS models were estimated, each for production and processing technologies. This is because the dependent variable, technology adoption (T_PROD and T_PROC), indicates the number of technologies adopted by each respondent (Table 1). In addition to women's agency, certain demographic variables and market strategies were included in the model as control variables. The demographic variables include household type, membership of VSLA, membership of producer group, and total land area. The headship of households has been shown to aid technology adoption. Most literature has shown that women in male-headed households depend on their husbands for decision-making on technology adoption. They only adopt after their husband might have done so. On the other hand, women in female-headed households are usually in control of their decision-making processes. In addition, membership of collectives such as VSLAs and producer groups provides critical information which members can leverage to aid their decision-making processes. Also, land area cultivated can give a glimpse of the wealth status of farmers (Boucher et al., 2008). It can be used to access credit as collateral and also provide opportunity to earn more income.

Descriptive data analysis

The result of the analysis shows that in Tanzania, slightly more than half of the respondents in the sample belong to male-headed households compared with about three-quarters in Malawi (Table 2). The study also reveals marked differences between membership of collectives between the two countries, as shown by membership of VSLAs and producer groups. For example, while virtually all the female respondents in Malawi belong to a VSLA, only about a third of the respondents in Tanzania are members. The reason for the low-level membership of groups such as VSLAs can be attributed to a culture of men dominating decision-making on economic matters, especially among married women (Maleko et al., 2013). In some instances, many married men restrict their wives from membership of these groups. In contrast, producer groups seem to be more prominent in Tanzania. About 64 per cent of women in our sample are members of producer groups compared with about 27 per cent in Malawi. A possible explanation for this is that in Malawi, women tend to be less integrated in value chains. Their lack of mobility, inadequate access to market, and restrictive social norms serve as barriers to interactions with value chain actors. These go a long way in excluding them from horizontal linkages such as producer groups (UN Women, 2016).

Table 2 Socio-economic characteristics of respondents

		Percentage (%)	
		Tanzania	*Malawi*
Geographic region	Masasi	30.8	–
	Nachingwea	69.2	–
	Kaomba	–	43.7
	Njombwa	–	18.3
	Dzoole	–	4.2
	Mwase	–	33.8
Marital status (M_STATUS)	Single	15.6	1.4
	Married	55.8	74.6
	Separated	10.4	4.2
	Divorced	3.9	2.8
	Widowed	14.3	16.9
Household type (HH_TYPE)	Male-headed	55.8	74.6
	Female-headed	44.2	25.4
Membership of producer group (M_PRODUCER)	Soya Groundnut Soya and groundnut	64.1	26.8
Membership of VLSA (M_VSLA)		33.3	98.6
Participated in crop production (Cr_I)		80.8	94.4
Crops cultivated (Cr_C)	Sesame	31.2	–
	Cassava	34.4	–
	Sesame and cassava	34.4	–
	Soya		9.1
	Groundnut		12.1
	Soya and groundnut		78.8
Land area cultivated (acres)	Less than 1	19.0	25.4
	1–5	77.7	71.7
	More than 5	3.2	2.8

With regard to involvement in crop production, a high proportion of the respondents in both countries, though higher in Malawi, were involved in crop production during the period. About 81 per cent of the respondents were involved in crop cultivation in Tanzania while about 94 per cent were involved in Malawi. In Tanzania, respondents who cultivated sesame, cassava, or both crops together were evenly distributed. The case was different in Malawi where about 79 per cent of the respondents cultivated soya and groundnut simultaneously. This is not unexpected because Malawi is the leading producer of legumes in Southern Africa. Also, improved varieties of legumes have the potential to improve food security and family nutrition for the poorest farmers, especially women farmers in Malawi (Snapp and Silim, 2002). This is due to their early maturity, low labour requirement, and high yield potential. In addition, intercropping of legumes such as groundnut with other crops assists in enhancement of soil fertility (Kerr et al., 2007). Our results show that the majority of women cultivated between one and five acres (0.4–2.0 hectares). This confirms previous studies in Tanzania which show that women farmers are mainly smallholders who had limited access to land for cultivation of their crops (Tulahi and Hingi, 2006; Mnenwa and Maliti, 2010).

Table 3 Adoption of agricultural technologies by women farmers (%)

	Tanzania (n = 78)	*Malawi (n =71)*
Production technologies		
Proper land selection	76.2	57.5
Minimum tillage	28.6	17.6
Soil erosion control	2.4	21.4
Certified seed	47.6	27.7
Intercropping	7.1	6.1
Cover crops and mulching	2.4	2.9
Weeding	66.7	42.9
Processing technologies		
Drying	73.1	85.9
Shelling	64.1	87.3
Sorting	37.2	76.1
Grading	17.9	56.3
Packaging	46.2	83.1
Storage	71.8	84.5

The breakdown of the adoption of different technologies in production and processing activities is presented in Table 3. The study shows that there are differences in the results. For example, production technologies seem to be highly adopted in Tanzania when compared with Malawi except in the case of soil erosion control. On the other hand, processing technologies were adopted more in Malawi. One possible explanation for this is the particular value chain. In Malawi, groundnut and soya beans have a shorter production period than cassava and sesame which are the targeted crops in Tanzania. As a result, there is a high probability that the respondents from Malawi would adopt processing technologies more than respondents from Tanzania.

The distribution of the variables used to construct agency is shown in Table 4. The findings from the table show that most of the respondents had a high agency.

Table 4 Women's conviction about important issues concerning their lives

	Strongly agree (%)	*Agree (%)*	*Indifferent (%)*	*Somewhat disagree (%)*	*Strongly disagree (%)*
I can always resolve household problems if I try hard enough	53.0	40.3	2.7	2.7	1.3
If somebody opposes me, usually I can find a way to get what I want	41.6	42.3	6.0	6.0	4.0
I always find some way to deal with problems that confront me	43.0	40.9	6.7	5.4	2.7
I can take action to improve my life	45.0	46.3	4.0	2.7	1.3
I can influence important decisions in my community	43.9	31.5	6.0	11.4	6.7

This is shown by the fact that most of the respondents either strongly agree or agree with each of the statements assessing their conviction on specific issues about their lives.

Factors influencing women's agency

In estimating the model, probit regression is utilized. This is suitable for the analysis where the dependent model is dichotomous. The purpose of the model is to estimate the probability that an observation with a particular characteristic will fall into a specific one of the two categories. The dependent variable, women's conviction (W_CONVICT), which measures women's agency, is constructed as a dummy variable (Table 5).

The results show that knowledge of gender issues, positive perception of gender roles, and large land size among women increase the probability of high agency by 0.356, 0.360, and 0.454, respectively. On the contrary, belonging to female-headed households and access to a variety of information sources decrease the probability of having high agency among women by 1.559 and 0.020, respectively (Table 5).

There are two possible explanations for low agency in the case of women in female-headed households. First, women in these households, especially widows, are usually the burden bearer and breadwinner within the households. They are faced with limited access to resources, technologies, and services such as extension services even more than women in male-headed households (Asfaw

Table 5 Factors influencing women's agency

	Coefficient	*S.E.*
HH_TYPE	–1.559**	0.722
M_STATUS	0.310	0.219
S_TRAINING	–0.224	0.190
P_INCOME	–0.063	0.138
G_PERCEPTION	0.360***	0.127
G_KNOWLEDGE	0.356***	0.138
F_SECURE	–0.022	0.115
LAND	0.454**	0.221
S_INFORMATION	–0.020*	0.112
SAVINGS	0.261	0.391
_cons	N/A	N/A
Obs	94	N/A
Log likelihood	–34.674666	N/A
LR Chi^2 (10)	32.94	N/A
Prob > chi^2	0.0003	N/A
Pseudo R^2	0.3221	N/A

Note: P value: *significant at 10%, ** 5%, and *** 1%

and Admassie, 2004). Second, gender norms and stereotypes within rural communities puts women at a disadvantage, and these are worse for women in female-headed households (Tenge et al., 2004). These limitations restrict the autonomy and ability of women in female-headed households to make purposeful decisions regarding their lives.

Similarly, while access to multiple information sources is expected to enhance women's agency, the findings in this study are contrary. This may be due to existing norms and regulations about agricultural support programmes which may favour men more than women. Hence, women's access to such programmes may not be beneficial to them. For instance, the World Bank (2009) gave examples of agricultural support programmes, such as credit provision targeted towards agricultural production, ending up benefiting men more than women because of the combination of gender-blind legislation and entrenched gendered norms which are biased towards men. In addition, in order for access to a variety of information sources to enhance the agency of women farmers, such interventions need to be gender-sensitive and gender-focused in planning and execution. This can be done by undertaking a gender analysis of the different phases of the programmes to determine whether it will add value to women and identify if women can be included in the activities that add most value.

As noted, the study found a probability of high agency among women with knowledge of gender issues, positive perception of gender roles and decision-making, and large land size. We also found women's perception of gender roles and decision-making had a positive influence on agency. Positive understanding of gender roles within the household, on issues such as sexual violence and workload sharing, help to improve women's self-esteem thereby enabling them to make effective choices in other spheres of life. For example, on issues of sexual decisions, women's sexual decision-making and behaviour are usually conditioned by society's prescription of perceived appropriate gender-specific behaviour. For example, women are made to endure sexual violence from male spouses under the pretext of maintaining family harmony (Humphries et al., 2012). However, in a few instances, these kinds of practices are being challenged by women. This is due to improvement in women's agency as a result of education and training which changes their positive perception of gender roles and decision-making. This is supported by previous findings such as Kabeer (2001) who argues that positive perception by women of their role in household decision-making, resulting from access to credit, leads to reduction in domestic violence and increase in assets. Such changes in perception have more impact when the money is utilized in areas of primary concern to the women, especially in starting or expanding their income-generating activities (Schuler et al., 1996). We also found a positive and significant relationship between knowledge about gender issues and women's agency. This is expected because knowledge empowers women to challenge the status quo of entrenched and discriminatory norms and beliefs which limit their ability to make decisions about issues that concern them within their households and community. Within the context of this study, this finding may be attributable to the influence of CARE FFBS introduced in the rural communities of Tanzania and Malawi. The emphasis placed on training

of gender issues puts the programme at an advantageous position over previous models, thereby playing a crucial role in enhancing the agency of the women. Similarly, the positive influence of perception of gender roles and decision-making on agency may be attributable to this.

Finally, we found a positive and significant relationship between land size and women's agency. This is because the area of cultivated land can give a glimpse of the wealth status of farmers (Boucher et al., 2008). Therefore, farmers with access to more land can cultivate more and subsequently have more money from sales of produce to procure agricultural technologies. Also, more land will require farmers to adopt new technologies in production as well as processing agricultural produce. Hence, women farmers who are members of collectives and who cultivate large land areas are in a better position to adopt agricultural technologies. In addition, land ownership often facilitates eligibility for access to other productive resources such as credit or producer associations (Manfre et al., 2013). For example, large land size gives farmers the opportunity to access credit because land can be used as a form of collateral for credit from formal financial institutions. Thus, access to land by women can enhance their capability to make choices since they can cultivate more land, have higher income, and procure technologies that can make their agricultural production more effective and efficient.

Influence of women's agency on technology adoption

After analysing the factors influencing women's agency, we explore the influence of agency on the production and processing technologies adopted by women farmers (Table 6). In doing this, we also introduce some control variables. These are household type, market strategies, membership of VSLA, membership of producer group, and land size. Our results reveal a statistically significant and positive effect of women's agency on adoption of production technologies. This implies that, keeping all other factors constant, high agency among women leads to a 0.327 unit increase in the number of adoptions of agricultural production technologies. However, we found an insignificant relationship between women's agency and adoption of processing technologies. The women in this study are smallholder farmers who engaged in production of groundnut, sesame, cassava, and soya bean as a source of livelihoods. For them to improve the productivity of their agricultural production, they have to be able to control the decision-making processes in the adoption of new agricultural practices.

These findings support previous findings such as those of Miller and Mobarak (2013) who conclude that successful strategies for distributing gender-specific technology will need to simultaneously address both the gender differences in preferences as well as intra-household differences in decision-making power. In a study of gender differences in the adoption of improved stoves, they found that women have a relatively stronger preference for improved and healthier stoves in particular, but lack the capacity to actualize their preference when either the technology is expensive or when their choice can subsequently be undone by their husbands. They definitely prefer the new stoves because they are healthier for both mother and children, and these are the

Table 6 Influence of women's agency on technology adoption

	T_PROD		*T_PROC*	
	Coefficient	*S.E.*	*Coefficient*	*S.E.*
W_CONVICT	0.327**	0.170	0.090	0.238
HH_TYPE	0.680*	0.406	0.466	0.569
M_VSLA	–0.545	0.495	1.837***	0.694
M_PRODUCER	0.774*	0.440	0.564	0.616
LAND	0.064	0.172	0.827***	0.241
MARKET_STR	0.199*	0.116	0.851***	0.163
_cons	–0.478	1.122	1.763	1.572
Obs	130		130	
F (6,123)	3.09		11.83	
Prob > F	0.0075		0.0000	
R^2	0.1310		0.3660	
Adjusted R^2	0.0886		0.3351	
Root MSE	2.0739		2.9052	

Note: P value: *significant at 10%, ** 5%, and *** 1%

important outcomes for the women. However, the lack of control over their decision-making and financial incapability denied them of the ability to exercise their agency. Similarly, Anderson et al. (2017) explain in a study of the intra-household power dynamics among 1,851 households in rural Tanzania that there are differences in the factors guiding intra-household decision-making dynamics between adult males and females. For example, the health of the woman is the main factor driving decision-making to adopt a particular technology in agriculture. Therefore, any new agricultural practices or technologies that do not take the health or physical capabilities of the women into consideration may not be adopted.

Conclusion and recommendations

Introducing new technologies and ensuring their uptake requires being sensitive to the context, especially among women farmers. The main theme of this study centres on women's agency and how this translates to technology adoption. Evidence from this paper supports the conclusion that women's agency is central to the adoption of agricultural technologies, especially in the case of production technologies.

The study found that women with knowledge on gender issues and positive perception of gender roles and household decision-making have a likelihood of high agency. Positive perception of gender issues and decision-making on issues such as sexual violence, workload sharing, and gender roles within the household enhance women's agency in other areas of life. This is because women's self-esteem and confidence is enhanced when they do not perceive themselves as inferior to the men. Hence, they are independent-minded and self-reliant in

their decision-making processes, especially on issues that are important to them. However, access to multiple sources of information may not enhance women's agency. This is due to non-integration of gender concerns in the planning and introduction of many sources of information. They are largely designed by men to take care of men's concerns. Furthermore, this article demonstrates that women who have strong conviction in making decisions have a higher likelihood of adopting agricultural production technologies. This implies that efforts by government and non-government agencies to invest in policies and programmes that build up the capability and decision-making potential of women would increase the adoption of agricultural technologies especially among rural women. This then necessitates the integration of gender concerns and the utilization of non-traditional approaches to address gender issues in agriculture. An example is the CARE FFBS which focuses on women's empowerment by using a gender-transformative approach. This approach encourages both men and women to understand gender roles as flexible and to encourage both men and women to try non-traditional gender roles.

Based on the results, we recommend that strategies and projects aimed at introducing new technologies should put into perspective the power of women to control decisions on issues that concern them. In addition, innovations and new strategies should be deployed to allow women to control the income from agricultural activities. For instance, direct payment of income into women's accounts or payment through mobile phones would enhance their power over income, thereby enhancing their autonomy in decision-making (Njuki et al., 2011). For example, promising rural finance initiatives such as the Warehouse Receipt System in Tanzania (William and Kaserwa, 2015) should be gender-sensitive in their implementation. Also, women farmers can be organized into cooperatives and trained on the requirements and standards of major buyers so that they can deal directly with large-scale processors. This is important in Tanzania and Malawi where women dominate processing activities (Stevenson and St-Onge, 2005; Forsythe et al., 2016). This allows them to maximize profits and thus gain more income by eliminating middlemen. The higher income can empower them to make choices on issues they value within their households. Similarly, efforts should be made to build rural women's capabilities by facilitating access to new technologies at an affordable rate. This will give rural women opportunities to access new information that may add value to their decision-making processes instead of depending on over-exploited, familiar sources of information.

Lastly, interventions to eradicate poverty and food insecurity must not only seek to facilitate access to resources and services like extension services; rather, it should also focus on enhancing women's capabilities, self-esteem, and confidence. That is, skills in gender roles and managing the intra-household bargaining process should be introduced to complement provision of resources and assets of agricultural production. For women in rural areas, this is an important measure of agency, as literature has shown that this strengthens their bargaining power within the household and empowers them to allocate resources to development outcomes of importance, such as improved health, nutrition, and education for their families.

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