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GENDER CONSIDERATION IN TECHNOLOGY DEVELOPMENT AMONG SMALLHOLDER FARMERS IN NORTHERN REGION, GHANA

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Abstract
Mass transfer of technology without understanding the special place of gender has often been received with mixed feelings, resulting in its misuse and its application. This paper presents results on gender consideration in the development of three maize and soybean technologies developed and promoted by Savannah Agricultural Research Institute (SARI) among 534 smallholder farmers in four selected districts in Northern region, namely West Mamprusi, Sawla-Tuna-Kalba, East Gonja and Zabzugu districts. Questionnaire, interview guide and desktop review were used as tools for the data collection. Descriptive statistics and Pearson's Chi-square test were used to analyse the data. The results revealed that generally very little attention was paid to gender issues in technology development with a p-value of 0.308 signifying that the gender of the respondents was independent of their involvement in technology and that there is no statistically significant association between gender and involvement in technology. Focused Group Discussions (FGDs) indicated that women farmers hardly come in contact with researchers and extension agents, as such their concerns with regards to technology preference and suitability were not considered. It is recommended that deliberate efforts be made during technology development to engage smallholder farmers in the identification and documentation of local needs regarding technologies so as to specifically include male and female expectations in the development of technologies.

Keywords: Gender, Technology, Technology Development, Farming System Approach

Introduction
Smallholder farmers in Africa have always been important agents for achieving and enhancing economic growth, food security and poverty reduction (World Bank, 2019). Available literature shows that there is an added value to agricultural production and productivity when technologies are sensitive to the gender context of users (Doss, 2018; UNECSO, 2003; United Nations, 2014). Historically, inequalities between males and females in most African societies have contributed to the accepted male-dominated culture. In many smallholder farms, technology is mostly available for use by men and in instances where it is available to women it becomes so bulky for them to use and

operate (World Bank, Food and Agriculture Organization [FAO], International Fund for Agriculture [IFAD], 2009). Therefore, when we talk of gender and technology, the questions that arise are whether the technologies are gender neutral or blind, hindering women's participation or not addressing gender concerns. Various reports by the World Bank (2012), Lefore and Weight (2017) and World Bank/FAO/IFAD (2009) have revealed that women, compared to men, have minimum access to extension services, as such they mostly use lower-level technologies because of problems with access, capacity, cultural limitations and insufficient interest in doing research on women's crops and livestock.

As a result, women's contribution to agriculture and the economy goes unnoticed in measuring performance economically (Parpart, Conelly, Conelly, 2000). Technology utilization in developing human and material resources could have been dramatically improved when women (like men) are included appropriately since they are responsible for 50-60 percent of agricultural production (FAO, 2011). For this reason, various literature on gender and agricultural systems makes it abundantly clear that understanding the need to develop technologies which are gender sensitive cannot be overemphasized (Adekunle, 2013; Apusigah, 2009; World Bank, 2012; Geertz, 2017). In Northern Region of Ghana, the context for this study, there are many examples of technologies (inoculation of soybeans with rhizobium, use of improved maize and soybeans varieties, organic soil amendments practices, inorganic amendment practices and integrated soil fertility management practice) introduced with great potential that have not been accepted by smallholder farmers (CSIR-SARI, 2013). The study however principally focuses on three (3) maize and soybeans technologies developed; namely, improved seed technologies through the introduction of hybrid varieties, combination of organic and inorganic soil amendments and, integrated approach to improving and managing soil fertility. These crops were chosen because, evidence shows that they will continue to be the most important drivers of agricultural growth, especially in the Northern Region, where there is a high incidence of poverty (Feed the Future, 2007; GSS, 2014). Similarly, within the USAID-funded Feed the Future (FtF) programme, soybean was selected as one of their intervention crops based on the fact that it contributes to the overall improvement, productivity of the maize cropping system, its potential for nutrition impacts, and its demand as an important input along with maize for livestock/poultry/fish feed (Masuda, & Goldsmith, 2009; El Agroudy, Mokhtar, Zaghlol & Gebaly, 2011). Consequently, this research sought to determine the extent to which gender influences the development of aforementioned technologies introduced by SARI for smallholder maize and soybean farmers in the Northern Region.

Materials and Methods

The paper used Farmer Based Organisations (FBOs) for data collection and analysis. FBOs are farmer community-based groups that come together to address agriculture related issues at both local and regional levels. Many tasks which include knowledge sharing among members, and the provision of feedback to researchers on new technologies introduced are by FBOs (Hans-Jorg, 2016). Extension agents and SARI have found that there are many advantages for farmers working in groups especially when the farmers are provided with requisite information on new technologies and allowed to work through practical adoption procedures with support from their peers (Bernard & Spielman, 2009; Salifu, Francesconi & Kolavalli, 2010).

The Study Area

The field survey for this study started from 2017 in the then Northern region before the split of the region into three administrative regions. The region was first stratified into four (4) geographical zones (north, south, east and west) because of the heterogenous (social-cultural dynamics) nature. A district each where maize and soybean are predominantly cultivated was purposively sampled from the four zones. The four (4) selected districts included West Mamprusi district which is now in the North East region, Sawla-Tuna-Kalba and East Gonja districts, now in the Savannah region and Zabzugu district in the now Northern Region. Figure 1 presents the map of the then Northern Region in national context, showing the respective study districts as at that time.

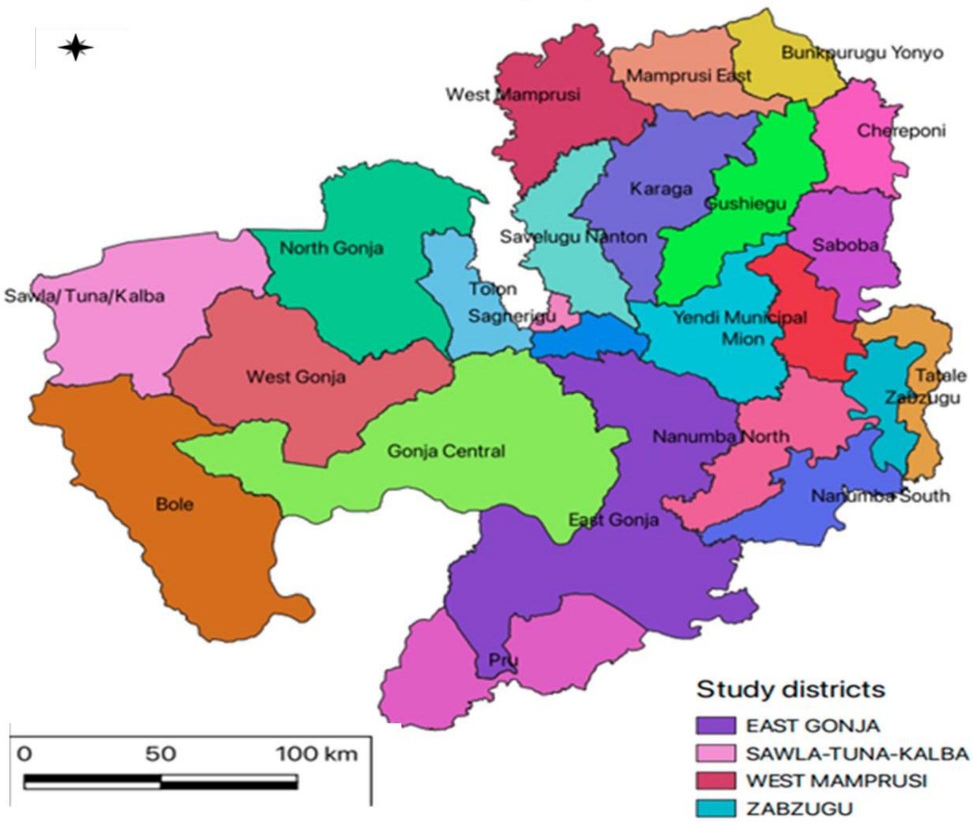

Figure 1: Map of previous Northern Region Showing Study Districts

Source: *Authors' Construct, 2017*

Sampling Technique

The multi-stage sampling technique was used to select the respondents for the study. In the first stage, the former Northern region was purposively selected for the study. Secondly, the region was stratified into four (4) geographical zones as north, south, east and west. The districts where maize and soybean are predominantly cultivated was purposively sampled from each of the four zones. These districts were selected purposively because the research was only interested in smallholder farmers who are into the cultivation of maize and soybean and these districts happened to be the leading districts in the production of maize and soybean. Simple random sampling was used to select twelve (12) communities; two from West Mamprusi, four from Sawla-Tuna-Kalba, three from East Gonja and three from Zabzugu districts. From the sampled twelve (12) communities, a total of 135 FBOs were sampled. The distribution of sampled FBOs in each sampled community and district is shown in Table 1. The individual farmers in each selected FBO were first stratified based on sex (male and female) and then sampled using simple lottery random sampling technique. Researcher scientists from SARI, and District extension officers of MoFA were also interviewed to triangulate the findings of the research.

Sample Size Determination

Cochran's (1997) formula was used to calculate the sample size, knowing the sample frame and total population. This was because the Cochran formula was found to be appropriate in determining large populations and further allows one to specify the desired level of precision. The mathematical formula is expressed in equation (1):

$$n = \frac{N}{1 + Ne^2} \qquad (1)$$

where n denotes sample size, N denotes population and e denotes margin of error. Table 1 gives a detailed estimation of the sample using the Cochran formula. A total of four thousand, five hundred and fifty-nine (4,559) farmers constituted the sample frame for the four study districts (MoFA, 2017). The greater the number of individual famers in an FBO, the higher the sample size, however, a higher number of FBOs in a particular district, does not always translate into having a higher number of famers.

Table 1: Sample Computation from the Four Districts

Districts	**Number of FBOs**	**Sampling Frame (Total Membership/Pop) (N)**			**Margin of error (e)**	**Sample size** $n = \frac{N}{1 + Ne^2}$		
		Males	**Females**	**Total**		**Males**	**Females**	**Total**
West Mamprusi	33	651	906	1557	10%	87	90	177
Sawla Tuna Kalba	28	199	96	295	10%	67	49	116
East Gonja	22	581	264	845	10%	85	73	158
Zabzugu	52	1038	824	1,862	10%	91	89	180
Total	135	2, 469	2, 090	4, 559	10%	330	301	631

Source: *MoFA and Author's Computations (2017*)

Zabzugu had the highest number of FBOs with a total of fifty-two (52) and a total of one thousand, eight hundred and sixty-two (1,862) individual farmers and as such had the highest sample size whereas, East Gonja had the least number of FBOs but with the second highest number of individual farmers therefore having a calculated sample size of one hundred and fifty-eight (158) individual farmers.

Data Collection

The data was collected using questionnaire, interview guide and desktop review of SARI policy documents and reports and website documents. The methods chosen allowed the researcher to elicit more information about maize and soybean small holder farmers and their use of technologies rather than choose methods based on prejudice of the significance of any one social construct (Katungi, 2006; Creswell, 2017).

Data Analysis

In assessing whether gender made any difference in respondents' view on the extent of technology development, respondents' agreement scores to some statements were disaggregated by sex and subjected to Chi-square test. The chi-square test was used because the variables sex and the responses to the questions were nominal variables.

The Chi-square model is presented as:

$$\chi^2 = \sum_{i=1}^{r}\sum_{j=1}^{c} \frac{\left(O_{ij}-E_{ij}\right)^2}{E_{ij}} \qquad (2)$$

χ^2 represent the Chi-square test of independence, O_{ij} represents observed values of two nominal variables, while E_{ij} refers to expected value of two nominal variables. However, degree of freedom is given by df = (r-1) (c-1), where r is the number of rows and c, the number of columns.

Where $E_{i.j}$ is computed as:

$$E_{i.j} = \frac{\sum_{k=1}^{c} O_{i.j} \sum_{k=1}^{r} O_{k.j}}{N} \qquad (3)$$

Where $E_{i.j}$ = expected value, $\sum_{k=1}^{c} O_{i.j}$ = sum of the i_{th} column $\sum_{k=1}^{r} O_{k.j}$ = sum of the k_{th} row and N= total number of observations. At the end of the test, if Chi-square calculated is greater than critical chi-square value at a pre-determined probability level preferably 5%, the null hypothesis is rejected.

Results and Discussions

Socio-demographic Characteristics of Respondents

Socio-demographic characteristics informs people's choice of assets, resources and the available options opened to them in pursuing beneficial livelihood outcomes (DFID, 2000; Kollmair & Gamper, 2002). Also, DFID (2000) pointed out that the way individuals are organised in a society significantly affects and alter their lifestyles in response to environmental challenges. Drawing from these perspectives and in view of the context of the study, the socio-demographic variables were considered.

In total three (3) maize and three (3) soybeans researchers were interviewed at SARI. Also, four (4) district extension officers of MoFA, at each of the study districts were interviewed to provide the supply side information to the study. Out of the ten (10) institutional actors interviewed, nine (9) were males. The units occupied by these SARI researchers were soybean/maize socioeconomic units, soybean/maize improvement programme and seed science units. More than half (55.6%) of the farmers were males with (44.4%) being females. Males were more than the females because the FBOs' information collected during the reconnaissance survey had 52% and 48% male and female representation respectively. An overwhelming majority (80.3%) of the farmers interviewed had no formal education, with only 1.9% having tertiary education. Also, as shown in Table 2, the average farming experience of the respondents in the production of maize and soybeans ranges from 3 to 7 years. The farmers were very experienced with a mean of 19 (SD = 11.7) years, cultivating an average of eight (SD = 7.4) acres.

Table 2: Socio-Demographic Characteristics of Respondent Smallholder Farmers

Distribution Frequency (n)/ Percentage (%)					
Variables	**Sawla Tuna Kalba**	**East Gonja**	**West Mamprusi**	**Zabzugu**	**Total**
Sex					
Male	72 (60)	93 (60)	52 (46.85)	80 (54.05)	297 (55.62)
Female	48 (40)	62 (40)	59 (53.15)	68 (45.95)	237 (44.38)
Total	120 (100)	155 (100)	111 (100)	148 (100)	534 (100)
Level of Education					
No formal education	85 (70.83)	137 (88.39)	98 (88.29)	109 (73.65)	429 (80.34)
Basic level	27 (22.50)	8 (5.16)	5 (4.50)	25 (16.89)	65 (12.17)
Secondary/Technical	5 (4.17)	7 (4.52)	5 (4.50)	8 (5.41)	25 (4.68)
Tertiary level	3 (2.5)	3 (1.94)	3 (2.70)	1 (0.68)	10 (1.87)
Other forms of education	0 (0)	0 (0)	0 (0)	5 (3.38)	5 (0.94)
Total	120 (100)	155 (100)	111 (100)	148 (100)	534 (100)
Continuous variables					
Variables	Mean	Std. Deviation	Minimum	Maximum	
Number of years of farming	19.1	11.7	2	70	
Size of farm cultivated	8.0	7.4	1	75	

Source: *Field Survey, 2018*

Gender Considerations in Technology Development

Gender refers to the different social roles and behaviour patterns assigned to males and females by society (Eckert & McConnell, 2013; Lalanne & Seabright, 2011). These gender roles and behaviour contribute greatly to technology adoption efforts (Wajcman, 2010; Wang & Shin, 2009). The way and manner technologies are identified and developed are perceived to influence its adoption by men and women differently (Wang & Shin, 2009; Oliveira and Martins, 2011). Further to this, Doss & Morris (2001) have indicated that men and women have different preferences to close the gendered productivity gap in agriculture, hence in developing technology there is the need to consider gender to make it beneficial to both men and women.

Farmers' Perspectives on Gender and Technology Development

From the perspectives of farmers' involvement in the development of the technologies, a number of questions were posed on gender considerations in technology development. Respondents' agreement scores to some statements were disaggregated by sex and subjected to Chi-square test and presented in Table 3. As shown in Table 3, the p-value of 0.308 signifies that the gender of the respondents is independent of their involvement in technology and that there is no statistically significant association between gender and involvement in technology. In other sense, there is no relationship between gender and the involvement of the technologies.

Table 3: Gender and Technology Development (in %)

Statement	**Response**	**Gender (%)**		**Test /Interpretation**
		Male	Female	
Were you Involved in Developing the technology	Yes	11.11	8.86	$\chi2$= 0.734; df=1; Pr =0.391 Statistically insignificant
	No	88.89	91.14	
	Total	100	100	
How Many Times have you been Contacted by Agricultural Personnel on the development of technologies during the last five years	1-5 times	23.91	25.74	$\chi2$= 8.103* df=2; Pr =0.088; Statistically significant at 10% level
	6-10 times	0.67	2.53	
	More than 15 times	17.17	20.68	
	None	56.90	51.05	
	Total	100	100	
Are There Technologies more likely to be for Men or Women?	Yes	17.93	14.96	$\chi2$= 2.879; df=2; Pr =0.237; Statistically insignificant
	No	80.34	84.61	
	Indifference	1.72	9.43	
	Total	100	100	
Who Decides Type of Technology Needed	Only men	1.37	0.86	$\chi2$= 5.977; df=5; Pr = 0.308; Statistically insignificant
	Both men and women	17.81	24.46	
	Communities	0.34	0	

	Institutions	38.01	36.05	
	Both communities and institutions	41.78	36.91	
	None of these	0.68	1.72	
	Total	100	100	

Source: *Field Survey, 2018*

In the second statement of how many times the respondents have been contacted by agricultural personnel on the development of technologies during the last five years, the Chi-square results of 0.088 indicates a statistically significant relationship between the statement and gender.

In terms of the statement of technologies that are more likely to be for men or women, 80.34% and 84.61% of males and females respectively answered no. The p-value of 0.237 in this case suggests no strong evidence to reject the null hypothesis and concludes that there is no relationship between gender and technologies that could be more likely to be for men or women.

On deciding the type of technology needed, the p-value of 0.308 for this statement suggests that there was no relationship between gender and the decision on the type of technology needed. Taken together, just one out of the four statements illustrated a relationship between the categorical variables. As such gender did not make any strong difference in respondents' views on the extent of technology development. This therefore means being a male or female in those statements do not differ significantly in respondents' average agreement scores on the other statements. However, Davis (2000) and Cochran (2011) proposed that the adoption of a new practice is predominantly driven by potential adopters' perception of its usefulness and the belief that using the practice will enhance performance and ease of use. Therefore, the failure to recognise this gender fact would reaffirm further the conclusions that technologies could have huge potential to reduce considerable time burden of women. Yet, their use and adoption among women would not be high and would continuously remain low as compared to the male counterparts. This is because, commonly-cited reasons for this have been the relatively weaker participation of women in priority-setting and research processes. This limits their ability and opportunity to influence the nature and development of technologies (Quisumbing et al., 2015; Ragasa & Mazunla, 2014).

As revealed during the field work, women participants at the FGD tended to agree that women farmers often do not get involved when researchers meet with farmers. They emphasised that only men are invited and the men do not tell or invite them to such meetings. Currently the new soybean variety they use, they said was given to them by their spouses. The male famers they said got the Afayak and Jenguma varieties from SARI who tested the varieties on the farms of the male famers. Women farmers in the various FGDs further revealed that women farmers hardly come in contact with researchers and extension agents and as such their concerns with regard to technology preference and suitability are not heard. An elderly woman participant made this comment:

I have been farming maize since I got married and my elder daughter now has six children, but I have never been invited to any maize or soybean farmers meeting with the agric. people. I have been seeing the men farmers meeting the agric. people and planting new things on their farms. Whatever new varieties and farming practices I am doing on my maize and soybean farms are what I saw the men do (FGD, 20th May 2019).

The women farmers at a FGD disclosed further that it was the village farmers association chairman that encouraged them to join one of the farming groups because the extension agent wanted them to add women to that group.

At a FGD a female participant mentioned that…

generally, it is the men who are contacted to take all the decisions concerning the introduction of new technologies, making it difficult for us the women to know what is discussed (FGD, 20th May 2019).

Other participants recalled similar meetings with opinion leaders by NGOs. This finding shows that men are more likely to attend meetings and gatherings organized by researchers, MOFA and NGOs and as such will be in a position to know what is happening.

Institutional Actors' Perspectives (MoFA and SARI) on Gender and Technology Development

To ensure technology developed are appropriate and fit into the farming system of Northern Ghana, SARI, the lead research institution, adopted a bottom-up approach in its research activities using the concept of Farming System Research (FSR) (CSIR-SARI, 2013). The FSR is based on the premise that research developed at experimental stations must be adapted to farm conditions and realities. This type of research approach has resulted in the modifications of the original technology implemented. For example, the recently released improved maize varieties (i.e., CSIR-Denbea, CSIR-Similenu, CSIR-Kum-Naaya and CSIR-Wang-Basig) were developed in 2017 based on farmers' concerns in the catchment area. The improved maize and soybean varieties were developed taking into consideration both male and female farmers' concerns on striga infestation free, droughts and early maturing varieties among others. Such concerns, as posited by Talukder and Quazi (2011) may be perceived as coming from individual farmers whose gender, beliefs, culture, religion and opinions are important. Similarly, Loevinsohn et al. (2013) observed that when new technologies show potential of solving a practical problem and align with farmers gender and preference then smallholders are more likely to adopt it. The researchers were further asked about the extent to which they considered gender in technology development. From responses to a questionnaire administered to SARI staff, 83.3% of the respondents stated that before developing the technology gender perspectives were considered. Additional, information gathered from interactions with SARI research scientists also revealed that the two improved varieties of soybean (i.e., Afayak and Jenguma) released by CSIR-SARI (2013) were developed with farmers' participation both in on-station and on-farm trials. This, they reported, was to improve on the chances of adoption by determining that the genotype varieties interact with the effects of farmers socio-cultural environment.

However, 16.7% of the researchers disagreed to considering gender before developing technologies. The researchers who said gender was included in technology development cited gender, culture, belief system and old practices as playing an integral role on how end users accept and utilize technologies. They further added that no technology so far is at variance with gender. Conversely, the respondents who did not agree to considering gender said technology developed was based on the immediate challenges of farmers (e.g., resistance to pests and disease, high yield, nutrient values, etc.) and not based on gender. The above results, however, suggest that researchers placed more emphasis on predetermined farmers' needs, the characteristics of the technologies, climatic and edaphic conditions aimed at increasing farm production. This trend revealed that generally very little attention is paid to gender issues in technology development, especially socio-cultural circumstances of women farmers.

Many of the research scientists interviewed were of the view that by engaging with farmers in identifying agricultural production problems and challenges, which form the basis for research, the gender aspects would automatically be captured and as such the technology to be developed as a solution to the problem would meet the aspirations of both sexes.

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The researcher sees this conclusion as a fallacy because women and men have different preferences in closing the gendered productivity gap in agriculture as shown in literature (Doss & Morris, 2001). This is because women in rural areas often have heavy workloads and schedules ranging from household chores to farm work and non-agricultural activities outside the households (Jingzhong, Huifang, Rao, Ding & Zhang, 2016). In view of this, the factors influencing the adoption of technology by this group of farmers will be dependent on the nature of their workloads and schedules (Theis et al., 2018). For instance, male farmers with large farm sizes are likely to adopt new technologies faster than women. This is because men could afford to devote part of their land and income to try new technologies unlike most women with smaller farm sizes (Mignouna et al., 2011).

A MOFA staff in an in-depth interview said:

Sometimes we receive requests from SARI research scientists asking us to bring farmers to observe research activities and for their views to be sought and used to make the research findings suitable for the farmers. In such situations we often include women farmers so that their views could also be heard (KII,16the February 2019).

MoFA staff further stated that women farmers are often involved in agricultural shows, farmers' field days, adaptive trial visits and other meetings with other farmers because the new service guide requires of agents to encourage gender participation in all activities. The following statements were further made by research scientists in response to the question 'to what extent do you consider gender issues in developing agricultural technologies?':

Our research outcomes do not discriminate on the basis of gender. Both men and women farmers benefit from the technologies we generate here. The improved crop varieties, best agronomic practices, and other research recommendations we generated are disseminated to both men and women farmers (KII, 3rd May, 2019).

Through FSR the needs of both men and women farmers are gathered and made available to guide our research activities. Therefore, the technologies we generate are done with the knowledge of both men and women farmers (KII, 3rd May, 2019).

Sometimes we consciously select both women and men farm to mount our on-farm adoptive trials to ensure that they are all involved in the process of research (KII, 3rd May, 2019).

The problem of pod shattering of soybean of which the recently released soybean varieties have been developed to solve was in response to complaints from women farmers who are involved in the harvesting and processing of soybeans. This demonstrates the importance of engaging both men and women farmers in the technology development process (KII, 3rd May, 2019).

It is the view of the researchers interviewed that by engaging and allowing the participation of both women and men farmers in assessing their problems and developing technologies to solve the problems, gender concerns would have been considered and the technology developed would be sensitive to both genders. This confirms postulations made by Muleme, Kankya, Ssempebwa, Mazeri & Muwonge (2017) that researchers assume that awareness, knowledge, attitude, and practices of technologies developed are related, and that awareness, knowledge and attitudes directly influence practice in technology adoption.

The researchers commented that the information from engaging with women farmers informed their efforts which led to the development of organic sources of soil fertility improvement technologies such as green manure, composting and soybean-maize rotation soil improvement practice. These organic soil fertility management practices, they said, were more appealing to women farmers because they cannot afford chemical fertilizers and also their fields are so degraded that only organic sources of soil improvement could have any effect.

Conclusion

The survey results revealed very limited involvement of male and female farmers in the technology development process. That apart the annual scientific reports' review did not at any point make reference to how socio-cultural factors were factored in the development of these technologies. The implication being that gender did not make any strong difference in respondents' views on the extent to which they were involved in technology development. This is because the research institutions assumed that through FSR the needs of both male and female farmers were made available to guide their research activities.

The participation of women and men farmers in technology development is not an end in itself but a means to generating technologies that work for all farmers. Without an in depth understanding of gender issues in the form of the societal, cultural and intra-household dynamics, women farmers' technology adoption will continue to be lower compared to men. Thus, efforts to promote technology adoption for agricultural development and women's empowerment would benefit from an understanding of intra-household control over technology to avoid interpreting technology adoption as an end in and of itself.

Recommendation

The survey results revealed very limited involvement of male and female farmers in the technology development process. In view of this, MoFA and research institutions should then make deliberate efforts to reach and engage male and female smallholder farmers to identify and fully document local needs and challenges related to technologies' acquisition. All stakeholders (women, men, farmers, researchers, and MoFA) should be involved in participatory technology development processes and the results shared.

Declaration of Interest Statement

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome. Also, an institutional-based ethical review of this project was conducted to establish relevance, benefits and minimize harm to all respondents prior to data collection.

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