Journal of International Agricultural and Extension Education

Volume 31 | Issue 1 Article 7

September 2024

Gender, Access to Agricultural Extension, and Seed Sourcing among Small-scale Farmers in Uganda

Helaina M. Curtin
University of Vermont, helaina.curtin@uvm.edu

Travis Reynolds
University of Vermont, twreynol@uvm.edu

Daniel Tobin
University of Vermont, daniel.tobin@uvm.edu

Recommended Citation

Curtin, H. M., Reynolds, T., & Tobin, D. (2024). Gender, Access to Agricultural Extension, and Seed Sourcing among Small-scale Farmers in Uganda. *Journal of International Agricultural and Extension Education, 31*(1), 109-126. DOI: https://doi.org/10.4148/2831-5960.1157

Gender, Access to Agricultural Extension, and Seed Sourcing among Small-scale Farmers in Uganda

Abstract

Agricultural extension services have been vital for the development of the agricultural sector across the globe, providing information and support for farmers to improve their productivity and economic livelihoods. However, studies have shown that access to extension services may not be equitable, mediated by factors such as gender, remoteness, and type of production system. In Uganda, resource constraints and gender shape which small-scale farmers access extension services. This study uses data from two waves of the Ugandan National Panel Survey (collected with support from the World Bank through the Living Standards Measurement Study – Integrated Surveys on Agriculture) to investigate associations between access to agricultural extension services, gender, and participation in the formal seed sector among Ugandan small-scale farmers. Seed choices warrant consideration, given that they are an important input for crop-based production systems and have anchored many development efforts seeking to enhance the productivity of small-scale farmers. Findings suggest that small-scale farmers are more likely to purchase seeds through formal market channels and to use improved crop varieties after receiving agricultural extension services. We also find that female-headed households are significantly less likely to access extension or participate in the formal seed sector, limiting their access to seeds of improved varieties, providing further evidence that women farmers often confront more resource and social constraints than men. These findings emphasize the need for continued attention to how agricultural extension services can exacerbate existing social inequities and highlight the importance of identifying effective policy approaches to mitigate gender gaps in accessing agricultural resources.

Keywords

Uganda, seed systems, agricultural extension, NAADS, gender

Funding Source

This study was supported by the National Science Foundation under Grant No. SMA-1950766. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

Gender, Access to Agricultural Extension, and Seed Sourcing among Small-scale Farmers in Uganda

Helaina M. Curtin, University of Vermont
Travis Reynolds, University of Vermont
Daniel Tobin, University of Vermont

Abstract

Agricultural extension services have been vital for the development of the agricultural sector across the globe, providing information and support for farmers to improve their productivity and economic livelihoods. However, studies have shown that access to extension services may not be equitable, mediated by factors such as gender, remoteness, and type of production system. In Uganda, resource constraints and gender shape which small-scale farmers access extension services. This study uses data from two waves of the Ugandan National Panel Survey (collected with support from the World Bank through the Living Standards Measurement Study – Integrated Surveys on Agriculture) to investigate associations between access to agricultural extension services, gender, and participation in the formal seed sector among Ugandan small-scale farmers. Seed choices warrant consideration, given that they are an important input for crop-based production systems and have anchored many development efforts seeking to enhance the productivity of small-scale farmers. Findings suggest that small-scale farmers are more likely to purchase seeds through formal market channels and to use improved crop varieties after receiving agricultural extension services. We also find that female-headed households are significantly less likely to access extension or participate in the formal seed sector, limiting their access to seeds of improved varieties, providing further evidence that women farmers often confront more resource and social constraints than men. These findings emphasize the need for continued attention to how agricultural extension services can exacerbate existing social inequities and highlight the importance of identifying effective policy approaches to mitigate gender gaps in accessing agricultural resources.

Keywords: Uganda, seed systems, agricultural extension, NAADS, gender

Funding source: This study was supported by the National Science Foundation under Grant No. SMA-1950766.

Introduction

Nearly two-thirds of the Sub-Saharan African population rely on agriculture as a primary source of income, and roughly 80% of these producers are small-scale farmers (World Bank, 2015). Although small-scale farmers play a key role in food production and food security globally (Fan & Rue, 2020), they regularly face high levels of poverty and food and nutrition insecurity (FAO et al., 2019). Following the 2008 food price spikes, renewed attention has been dedicated to the agricultural sector in Sub-Saharan Africa, perhaps most prominently through the African Green Revolution which has received substantial investment from the Rockefeller Foundation and the Gates Foundation through its Alliance for a Green Revolution in Africa (AGRA) initiative (World Bank, 2007). Since 2006 AGRA has sought to promote adoption of high-yielding seed technologies in Africa, where uptake had originally been limited during the first Green Revolution, even despite widespread adoption of technologies across much of Latin America and Asia (Wise et al., 2020). Reflective of the approach implemented during the original Green Revolution, the dissemination of agricultural technologies through extension services continues as a core agricultural development strategy (Ariga et al., 2019).

Agricultural extension services have been central in the development of agriculture across the globe, supporting farmers to improve productivity and enhance economic livelihoods (Aremu & Reynolds, 2024). Originating in the Global North during the nineteenth century, agricultural extension was established as a service to "extend" knowledge and information from academic research institutions to rural farmers, with focus on technology transfer, management skills, and informal education (Jones & Garforth, 1997). During the first Green Revolution, extension services played a crucial role diffusing seeds of improved crop varieties and other technologies (i.e., fertilizers, pesticides, etc.) to farmers (Parayil, 1992; Pray, 1981). One important aspect of agricultural extension services is the link it provides between plant breeders and farmers (Altalb et al., 2015). Seeds have long been central to development efforts, with potential to help farmers achieve yield potential and position them to access more competitive markets (Scoones & Thompson, 2011). Consequently, strengthening the formal seed sector (i.e., improved crop varieties developed through scientific plant breeding and distributed commercially) is a hallmark characteristic of the African Green Revolution (Shilomboleni, 2017), which aims to increase agricultural productivity in Africa with improved technologies (Blaustein, 2008) including disseminating such technologies through agricultural extension programs (Aremu et al., 2015).

Despite the global importance of extension in serving as a key link between researchers and farmers, there have been critiques. Multiple studies have highlighted that access to extension services is often not equitable, mediated by such factors as gender, remoteness, and type of production system (e.g., subsistence versus market-oriented) (Aremu & Reynolds, 2024; Bryan et al., 2017; Ragasa, 2014; Reynolds et al., 2020). Because extension often connects farmers to technologies and resources like seeds, differential access may intensify social inequities (Fisher et al., 2019). Men farmers are often better connected to the formal seed system, in part because they typically enjoy more access to land, credit, and information than women farmers (Fisher & Carr, 2015; Negin et al., 2009). On the other hand, women farmers often rely on informal seed systems (i.e., decentralized, farmer-managed networks of seed cultivation and distribution) to access preferable local varieties (David, 2004). The informal seed system can provide access to traditional and/or locally adapted varieties which women typically prioritize for food and nutrition security, whereas the formal seed system is more often focused on high-yielding, market-oriented crops more often prioritized by men (Reynolds et al., 2020).

At the same time, the technologies emphasized by extension services often do not account for the needs, preferences, and resources of women farmers (Gengenbach et al., 2018; Quisumbing & Pandolfelli, 2010). Social barriers impeding women's agricultural decision-making power (Bryan et al., 2017), combined with less access to information regarding improved agricultural technologies (Fisher & Carr, 2015), pose further challenges to women farmers deriving benefit from extension services (Ragasa, 2014). To ensure progress towards equity in agricultural development in Africa, a better understanding is needed surrounding disparities in access to agricultural extension among women and men farmers and, in turn, adoption of productivity-enhancing technologies such as improved seed.

This study explores how access to agricultural extension relates to seed sourcing trends among small-scale farm households in Uganda, with particular focus on differential access to extension among women and men. Extension programs in Uganda take place through the National Agricultural Advisory Service (NAADS) (AfranaaKwapong & Nkonya, 2015), which uses a pluralistic system of delivery, including a mix of governmental institutions, non-governmental organizations, and private firms working to support small-scale farmers (Eicher, 2007). We focus on the years 2015-2016 and 2019-2020, which provide an interesting point of comparison as the country implemented its National Seed Policy in 2018 that seeks to provide a framework for seed sector development. Drawing on data from the Living Standards Measurement Study – Integrated Surveys on Agriculture (LSMS-ISA) we specifically examine how seed purchasing and use of improved seed relates to extension access and gender of the head of household, controlling for other farm, household, and community-level factors.

Purpose and Research Questions

Although access to agricultural extension, seed sourcing, and gender have all been identified as important considerations to inform agricultural development policy and programs, they have seldom been analyzed all together (Pan et al., 2018; Puskar et al., 2021). Previous studies have found that access to extension services can enhance farmer adoption of improved crop varieties (Dibba et al., 2015; Simtowe et al., 2019). Those studies that have explored the associations between agricultural extension and gender have found that men often enjoy better access to extension services than women (Fisher et al., 2019; Ragasa, 2014). In part reflecting gendered differences in access to extension, some studies have also found that men often have better access to improved crop varieties than women (Adzawla et al., 2019; Dibba et al., 2015). The intersection of access to extension, gender, and seed sourcing can thus offer important insights into which farmers have access to the kinds of technologies that are theorized to enhance agricultural productivity and, in turn, wellbeing. Because agricultural extension services provide an opportunity to reach underserved segments of populations, such as women small-scale farmers, understanding women's engagement with extension and strategies for seed sourcing is important for supporting the development of appropriate, targeted, and effective agricultural strategies and policies.

Uganda has long prioritized development and dissemination of improved seed, including through its 2018 National Seed Policy, and has also been a target of funding for other seed-related initiatives including AGRA (Blaustein, 2008), making the country an interesting case study to examine how gender and extension relate to seed purchasing and improved seed use. Agricultural extension in Uganda has undergone many changes throughout history: from a focus

on the production of cash crops under colonial reign to assistance and investment from USAID in 1964 and the establishment of NAADS in 2002 (Semana, 2008). NAADS is structured as a publicly-funded program that relies heavily on partnerships with the private sector and civil society to deliver agricultural extension in line with government policy under five components: 1) advisory and information services to farmers, 2) technology development and linkages with markets, 3) quality assurance, 4) private sector institutional development, and 5) program management, monitoring, and evaluation (Kyohairwe & Tibaijuka, 2013). This approach has been viewed as effective in supporting profitable agricultural enterprises and disseminating improved technologies to create products with market potential (AfranaaKwapong & Nkonya, 2015). However, NAADS has also been critiqued for organizational inefficiencies and unclear roles across the public and private sectors, contributing to ongoing obstacles regarding policy implementation (Rwamigisa et al., 2018). To improve the functioning of NAADS, an improved understanding of whether its services are equitably accessible to different groups of small-scale farmers constitutes an important area of inquiry.

The purpose of this research is to examine the influence that NAADS extension services and outreach efforts may have on how Ugandan small-scale farmers source seeds, with a particular focus on the gender of the head of household. The study was guided by the following research questions: 1) To what degree is there an association between access to agricultural extension services and sourcing seed from the formal seed sector (proxied by purchasing seed and using improved seed)?; 2) To what degree is there an association between access to agricultural extension services and gender of the head of household?; 3) To what degree is there an association between gender of the head of household and sourcing seed from the formal seed sector?; and 4) To what degree does gender of the head of household moderate the association between access to agricultural extension and sourcing seed from the formal seed sector?

Methods

Data and Variable Specification

Data were drawn from the 2015-2016 and 2019-2020 Uganda National Panel Surveys (UNPS), conducted as part of the Living Standards Measurements Study – Integrated Surveys on Agriculture (LSMS-ISA) collected by the Ugandan Bureau of Statistics with support from the World Bank. This time frame was selected as the Ugandan National Seed Policy was implemented in 2018; we thus used the 2015-2016 and 2019-2020 UNPS data to observe changes over time, pre- and post- National Seed Policy. The UNPS is representative at national, rural/urban, and regional levels. The panel dataset is based on a combination of household surveys (completed by all households in the National Panel Survey), agricultural surveys (completed by all household who reported any agricultural activities), and community surveys (providing information on access to resources and information among groups of sampled households in a given locality). The household surveys provide household and demographic characteristics including one of our main variables of interest, the gender of the head of household. The agricultural surveys provide the remaining three main variables of interest, including self-reported seed purchases, self-reported use of improved seed, and whether farm households had accessed extension services. Additional household and farm characteristics including education of the head of household, credit use, farm size, and rural/urban status are used in robustness checks. We further explore community characteristics that might relate to

extension access and use drawn from the community surveys, including presence of a local farmers' group.

Seed Sourcing and Use of Improved Seed

We measured seed purchases using the yes/no responses to the question "Did you purchase any seed/seedlings for this crop?". Those who answered "yes" were coded as a 1, which we assume represents use of the formal seed sector; "no" responses were coded as a 0, assuming to represent no use of the formal seed sector and instead reliance on informal markets and/or own saved seed stock. Seed purchases from markets are commonly used as a proxy for formal seed sector participation in the Global South (Kansiime 2014; Sperling & Cooper, 2004; Wattnem 2016). In contexts where quality assurance mechanisms are in place, seed purchased from the formal seed sector has been associated with higher germination and higher yields (Ariga et al., 2019; Croft et al., 2017), making increasing formal sector engagement a core component of many extension programs in Africa (Otieno et al., 2017; Pan et al., 2018). As an additional proxy for participation in the formal seed sector, we consider responses to the survey question "What type of seed did you use for this crop?" Those who responded "improved seed" (versus traditional seed) are assumed to have made at least some use of the formal seed sector.

Extension Access

In Sub-Saharan Africa, agricultural extension facilitates technology transfer from research institutions to farmers, provides technical support for farmers groups, and can help build and coordinate partnerships with aligned organizations (Davis, 2008). We measured access to agricultural extension using responses to the question "Did anyone in this household receive advice/information about agricultural/livestock activities from any of the following sources in the past 12 months?". The Uganda National Panel Survey captures access to extension from multiple sources, including NAADS directly, as well as support from input suppliers, non-governmental organizations, and other farmers participating in extension efforts. Farm households reporting "yes" to any of these sources of extension support are coded as having accessed extension services.

Head of Household Gender

Previous literature suggests that women farmers tend to have limited participation in agricultural decision-making (Bryan et al., 2017), due to having less access to information regarding improved agricultural technologies (Fisher & Carr, 2015). Additionally, women farmers are often more reliant on informal seed systems, as improved technologies do not always account for their needs, preferences, or resources (David, 2004; Otieno et al., 2021; Quisumbing & Pandolfelli, 2010). In our analysis, we include gender of the household head, specifically female-headed households (FHH), a common approach in previous studies, although admittedly one that also has its limits in that it is unable to consider variation among women and men within the household (Quisumbing et al., 2014).

While the dataset does not tell us exactly why a given household is female- or male-headed, we can observe that female-headed households are in many cases headed by women who are widowed (40%) or divorced/separated (22%), and in some cases by women in polygamous unions (20%), and only rarely in monogamous unions (15%). In contrast, the overwhelming majority of male-headed household heads are either married monogamously (74%) or polygamously (16%). Female-headed households also on average have fewer members

present - 4.7 vs. 5.2 for male-headed households - possibly reflecting absence and/or migration of a spouse or senior male household member.

Additional Variables

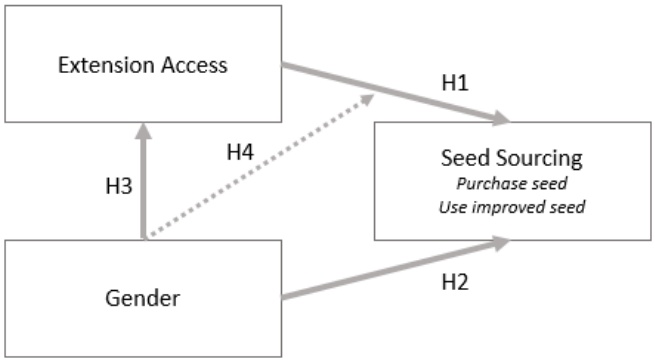
The final model also includes controls for several farm and household characteristics drawn from the literature on extension access and seed choice in Sub-Saharan Africa. These include education level of the head of household (Shikuku et al., 2019), use of credit (Quisumbing & Pandolfelli, 2010), farm size (Simtowe et al., 2021), rural or urban status (Witinok-Huber et al., 2021), and presence of a farmers' group in the respondent's community (Kyohairwe & Tibaijuka, 2013).

Analytical Framework

The analytical framework outlined in Figure 1 postulates that 1) extension access is associated with sourcing seed from the formal seed sector (H1), 2) head of household gender is associated with sourcing seed from the formal seed sector (H2), and 3) head of household gender is associated with extension access (H3). We further hypothesize that head of household head mediates the relationship between extension access and sourcing seed from the formal seed sector (H4). Building on previous studies (Adzawla et al., 2019; Dibba et al., 2015; Fisher et al. 2019; Ragasa, 2014; Simtowe et al., 2019), we seek to advance understanding of these relationships by considering all three variables (extension access, gender of household head, and seed sourcing) together.

Figure 1

Analytical Diagram.



Data analysis

All statistical analyses were conducted in Stata 16.0. To examine possible associations between seed sourcing and receiving extension services among female- and male-headed households, we used binary logistic regression to consider the use of the formal seed sector as a function of extension access and gender. The outcome of interest was seed sourcing, where 0 represents no use of the formal seed system (i.e., the household relies on own-saved seed or informal networks) and 1 represents use of the formal seed system. Households that did not use seeds (e.g., non-farm households and livestock-only households) were omitted from the analysis.

The initial model takes the general form:

$$Y_{seed_i} = \beta_0 + \beta_1 X_{Extension} + \beta_2 X_{Female} \quad (1)$$

where Y_{seed_i} is a binary variable indicating seed purchase (purchase any seed = 1) or use of improved seed (use improved seed =1), the coefficient β_1 reflects the association between accessing extension services and participation in the formal seed system (seed purchasing or improved seed use), and β_2 is the association between gender (female=1) and seed choice. A second set of models then examine the association between accessing extension services and seed choice among female-headed households only:

$$Y_{seed_i} = \beta_0 + \beta_1 X_{Extension} \mid X_{Female} = 1 \quad (2)$$

The next models include a series of control variables consisting of common farm and household characteristics drawn from the literature on agricultural extension and seed technology adoption. These expanded models takes the general form:

$$Y_{seed_i} = \beta_0 + \beta_1 X_{Extension} + \beta_2 X_{Female} + \beta_3 X_{Education} + \beta_4 X_{Credit} + \beta_5 X_{Farmsize} + \beta_6 X_{Rural} + \beta_7 X_{Farmersgroup} \quad (3)$$

to consider the associations between extension access, gender, and seed choices while controlling for the potential confounding effects of education, as well as farm size and access to credit (both proxies for household wealth and resources), and finally whether the household was located in a rural or urban area and had access to a farmers' group.

A final set of models look directly at the possible interaction between extension access and gender in shaping farmer seed choices, with the form:

$$Y_{seed_i} = \beta_0 + \beta_1 X_{Extension} + \beta_2 X_{Female} + \beta_{12} X_{Extension\ x\ Female} \quad (4)$$

where β_1 and β_2 represent the main effects of extension and gender on seed choice, and β_{12} is the interaction term, reflecting the potential additional effect of extension access among female-headed households.

Results

Extension Access, Seed Purchasing and Improved Seed Use

The overall pattern in extension services access and seed choices (seed purchases and improved seed use) is summarized in Figures 2-3. In the years 2015-2016, small-scale farmers

who received extension services were relatively more likely to purchase seed (49.2%) compared to those who did not report receiving extension services (23.8%) (χ^2=22.57, p<0.001). These differences are somewhat muted (and no longer statistically significant) in the subsequent 2019-2020 survey, where 36.5% of farmers who reported receiving extension services purchased seeds as compared to 31.1% of farmers who purchased seeds without receiving extension services (χ^2=2.22, p=0.136). Farm households who received extension services used improved seed at much higher rates than those who did not receive extension services in both 2015-2016 (χ^2=77.29, p<0.001) and in 2019-2020 (χ^2=44.79, p<0.001) (Figure 3).

Figure 2.
Percentage of small-scale farmers who received extension services and purchased seed in Uganda in 2015-2016 (n=2,695) and 2019-2020 (n=2,593).

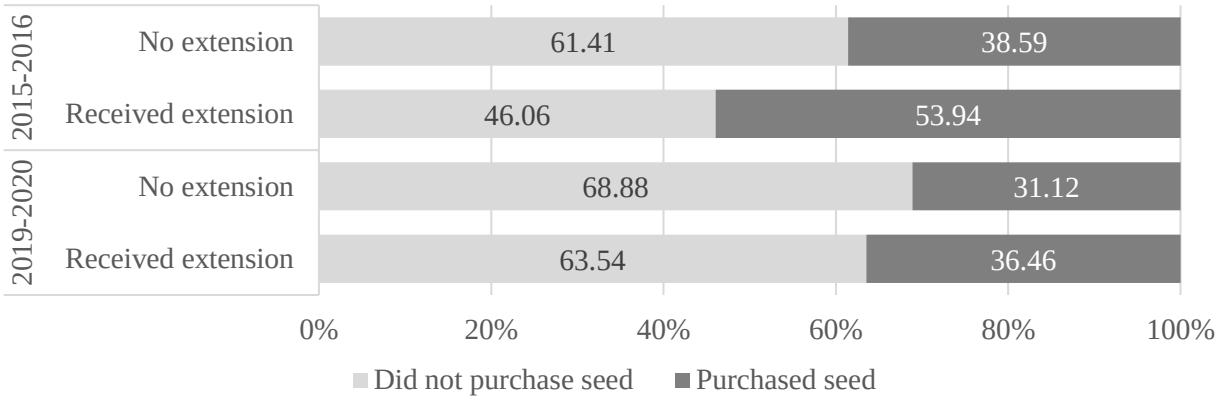


Figure 3.
Percentage of small-scale farmers who received extension services and used improved seed in Uganda in 2015-2016 (n=2,695) and 2019-2020 (n=2,593).

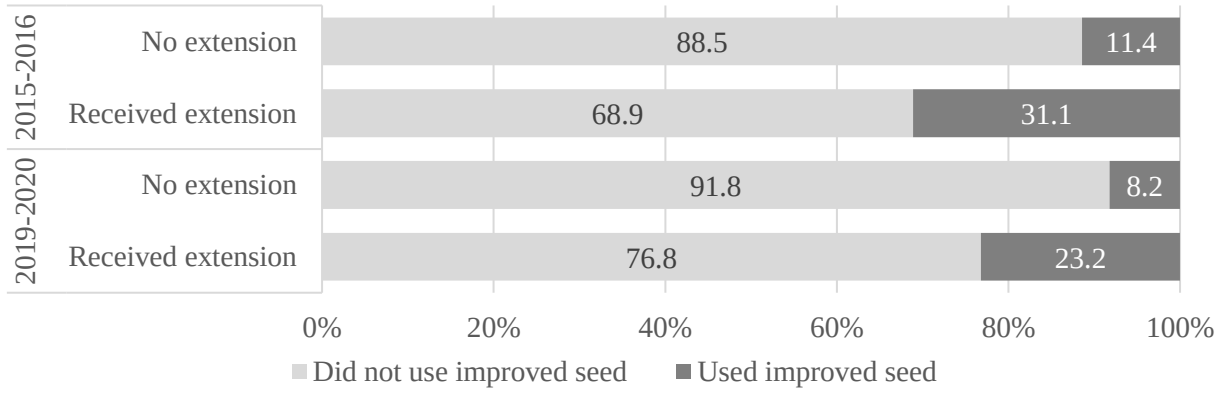


Table 1 reports the results of binary logistic regressions for seed purchasing and improved seed use as a function of gender and extension access. Model 1 considers seed purchases and improved seed use among all households in 2015-2016 and in 2019-2020, including a variable for female-headed households. Model 2 examines patterns in seed purchases and improved seed

use within the subsample of female-headed households in each survey only. In 2015-2016, farm households overall were 1.66 times more likely to purchase seed from the formal seed sector if they reported receiving extension services, and more than 3.28 times as likely to use improved seed ($p<0.001$). Considering the sub-sample of female-headed households only (Model 2), female-headed households were two times more likely to purchase seed if they received extension services in 2015-2016, and over three times as likely to use improved seed. Overall, female-headed households were less likely to purchase seed or use improved seed, but their likelihood of doing so was substantially higher when they had access to extension. In the more recent 2019-2020 survey data, the gender coefficients are largely consistent, with female-headed households significantly less likely to purchase seed or use improved seed than male-headed households. Access to extension also remains strongly associated with improved seed use in the overall sample: in 2019-2020 farm households with access to extension were 3.26 times more likely to use improved seed than those without extension access ($p<0.001$). However, there is no longer a significant association between extension access and seed purchasing in the 2019-2020 survey data. And among the sub-sample of female-headed households, neither association (between receiving extension services and purchasing seed or using improved seed) is significant.

Table 1

Binary logistic regression for purchased seed and improved seed use as a function of extension access and gender of the household head, 2015-2016 (n=2,221) and 2019-2020 (n=2,485).

	Model 1 2015-2016 Full sample n=2,221	**Model 2** 2015-2016 Female-headed n=655	**Model 1** 2019-2020 Full sample n=2,485	**Model 2** 2019-2020 Female-headed n=784
Seed purchase				
Extension access	1.661***	2.099**	1.233	1.576
Female-headed household	0.661***		0.679***	
Constant	0.968	0.628***	0.105***	0.340***
Improved seed use				
Extension access	3.281***	3.249***	3.258***	2.190
Female-headed household	0.651***		0.546***	
Constant	0.179***	0.116***	0.105***	0.060***

*Note. *** p<.01, ** p<.05, * p<.1.* Reported coefficients are odds ratios.

To test the robustness of the findings that female-headed households are less likely to purchase seed or use improved seed as compared to male-headed households, we add other relevant variables to the regression models. For brevity we present the results for 2019-2020 only in these robustness tests (Table 2). These expanded models include additional variables from the individual surveys (education and credit use), farm surveys (farm size), and the household surveys (rural/urban status and access to a community group) in the UNPS data.

Table 2

Binary logistic regression for purchased seed and improved seed use as a function of extension access and gender with additional household, farm and community characteristics 2019-2020 (n=2,270).

	Model 3: Purchased seed			Model 3: Improved seed use		
	Coef.	**St.Err.**	**p-value**	**Coef.**	**St.Err.**	**p-value**
Female-headed household	0.568***	0.057	0.000	0.554***	0.097	0.001
Extension access	1.089	0.197	0.636	2.761***	0.599	0.000
Education (Ref: None)						
Some primary	1.246*	0.144	0.056	1.277	0.251	0.214
Completed primary	1.060	0.240	0.796	1.024	0.379	0.948
Some secondary	1.199	0.179	0.226	1.453	0.347	0.117
Secondary or above	1.150	0.250	0.521	1.567	0.499	0.159
Credit	1.066	0.127	0.590	0.903	0.179	0.608
Farm size (log)	1.076	0.053	0.138	1.447***	0.114	0.000
Farmers group	0.976	0.303	0.938	0.744	0.301	0.466
Rural	1.019	0.160	0.141	1.225	0.292	0.395
Constant	0.497***	0.081	0.000	0.059***	0.017	0.000
Mean Y_i 0.345	SD	0.475	Mean Y_i	0.10	SD	0.302
Pseudo R^2 0.016	N	2270	Pseudo R^2	0.057	N	2270
χ^2 47.53	Prob > χ^2	0.000	χ^2	84.52	Prob > χ^2	0.000
AIC 2899.38	BIC	2962.39	AIC	1430.85	BIC	1493.86

*Note. *** p<.01, ** p<.05, * p<.1.* Reported coefficients are odds ratios.

When adding the variables education, use of credit, farm size (logged to account for uneven distribution), rural status and presence of a farmer's group to our base model, we continue to observe similar results: female-headed households are significantly less likely to purchase seed or use improved seed than male headed-households ($p<0.001$). Extension access is not associated with a greater likelihood of purchasing seed after controlling for other factors but remains positively associated with improved seed use ($p<0.001$). Among other covariates, household heads with some primary education are more likely to purchase seed than those with no education ($p=0.056$), while larger farms are significantly more likely to use improved seed ($p<0.001$).

In a final step, we used an interaction model to further test the hypothesis that access to extension has a significant association with seed sourcing activities among female-headed households (as per Table 1). In the 2015-2016 data (Table 3), we continued to observe that female-headed households are less likely to purchase seed, and that access to extension is positively associated with seed purchasing, with households with extension access more than 3 times more likely to purchase seed ($p<0.001$). The non-significant interaction term suggests the association between extension access and seed purchasing is no stronger among female-headed households as compared to male-headed households; female-headed households that received extension services are no more likely to purchase seed than male-headed households with extension access. The pattern is nearly identical for improved seed use – female-headed households are less likely to use improved seed, and when able to access extension are no more likely to use improved seed than male-headed households with extension access.

Table 3
Interaction Model 2015-2016 (n=2,221).

		Model 4 Seed purchase – interactions			Model 4 Improved seed use - interactions		
		Coef.	**St.Err.**	**p-value**	**Coef.**	**St.Err.**	**p-value**
Female-headed household		0.550***	0.097	0.000	0.652***	0.100	0.000
Extension access		3.353***	0.609	0.000	3.289***	0.000	0.000
Female-headed household x Extension access		1.168	0.476	0.380	0.988	0.378	0.975
Constant		0.143***	0.012	0.000	0.179***	0.013	0.000
Mean Y_i	0.129	SD	0.335	Mean Y_i	0.158	SD	0.365
Pseudo R^2	0.040	N	2221	Pseudo R^2	0.034	N	2221
χ^2	68.00	Prob > χ^2	0.000	χ^2	65.14	Prob > χ^2	0.000
AIC	1645.92	BIC	1668.74	AIC	1884.69	BIC	1907.51

*Note. *** p<.01, ** p<.05, * p<.1.* Reported coefficients are odds ratios.

In the 2019-2020 data we again see no disproportionate effect of extension access on seed purchasing or improved seed use among female-headed households in the sample. Table 4 suggests that in the 2019-2020 data, female-headed households remain less likely to purchase seed or to use improved seed. Extension access remains significant and positively associated with improved seed use among all farm households, with no apparent association with purchasing seed from the formal seed system. There is no added effect of extension among female-headed households for either seed choice considered.

Table 4
Interaction Model 2019-2020 (n=2,485).

		Model 4 Purchased seed – interactions			Model 4 Improved seed use - interactions		
		Coef.	**St.Err.**	**p-value**	**Coef.**	**St.Err.**	**p-value**
Female-headed household		0.665***	0.066	0.000	0.579***	0.105	0.000
Extension access		1.146	0.211	0.460	3.529***	0.744	0.000
Female-headed household x Extension access		1.375	0.521	0.400	0.621	0.338	0.380
Constant		0.512***	0.027	0.000	0.104***	0.009	0.000
Mean Y_i	0.315	SD	0.465	Mean Y_i	0.093	SD	0.290
Pseudo R^2	0.006	N	2485	Pseudo R^2	0.032	N	2485
χ^2	19.43	Prob > χ^2	0.000	χ^2	48.59	Prob > χ^2	0.000
AIC	3085.45	BIC	3108.72	AIC	1496.78	BIC	1520.04

*Note. *** p<.01, ** p<.05, * p<.1.* Reported coefficients are odds ratios.

Conclusions and Study Implications

This study draws on data from two waves of the Uganda National Panel Survey to explore how access to extension services relates to seed sourcing trends, with a particular focus on gender of the head of household. Building on many previous studies of gendered differences of agricultural extension access and seed purchasing that utilize a range of methods in a variety of

contexts (Bryan et al., 2017; Fisher & Carr 2015; Otieno et al., 2017; Quisimbing & Pandofelli, 2010; Rwamigisa et al., 2018), our analysis confirms that female-headed households in Uganda are generally less likely to purchase seed from the formal seed sector or to use improved seed than male-headed households, even after receiving extension services. These disparities remain even after accounting for other variables relating to socioeconomic status and resource access, which suggests further attention to gender gaps in extension and seed access is needed to ensure extension services and agricultural development strategies are targeted and appropriate.

Although all small-scale farmers with access to extension are more likely to engage in seed purchasing and improved seed use, women farmers still purchase seed and use improved seed at much lower rates than men farmers. Yet, we find that if women farmers were to have access to agricultural extension, they would be significantly more likely to purchase seed. Consistent with previous literature (Bryan et al., 2017; Negin et al., 2009; Ragasa, 2014; Reynolds et al., 2020), the findings from this study contribute additional evidence that discrepancies in accessing agricultural extension can be at least partly attributed to social identities (gender in this case). Since agricultural extension often connects farmers to improved agricultural technologies, differential access may further intensify resource related inequities (Fisher et al., 2019).

Yet, our findings demonstrate that if women had access to extension, they would be more likely to purchase seeds and use improved seeds, suggesting that gender inclusivity must be a priority for extension should it view one of its roles as encouraging technological uptake among all small-scale farmers. In the 2019-2020 analysis, we find a much-lessened effect of extension on small-scale farmers' seed choices. Given the passage of the 2018 National Seed Policy, one logical explanation is that extension access became more widespread and accessible, especially for female-headed households, diminishing the average effect of extension services (which in the past may have only reached those households most likely to purchase seed). Future studies should further investigate if and how the 2018 National Seed Policy influenced how and with whom extension does its work and what the resulting outcomes of those changes are.

To test the explanatory power of gender on access to extension services and seed source, we continued our analysis by building in additional variables, including education, rural status, farm size, credit use, and presence of a farmer's group in our second analysis. Consistently, even in the most saturated model (Table 2), we find that the results remain consistent: 1) female-headed households are much less likely to purchase seed or use improved seed than male-headed households and 2) households with access to extension services are associated with improved seed use, with farm size emerging as another important predictor. In sum, it appears that male-headed households with larger farms and access to extension services are more likely to purchase seeds and use improved seeds. These findings are consistent with the resource constraints that women farmers face identified by previous studies (Fisher & Carr, 2015; Quisumbing & Pandolfelli, 2010).

Finally, we use interaction models to test for an independent effect where gender is associated with seed purchasing. However, we found no difference in effectiveness of extension between female- and male-headed households. Ultimately, given women's relatively lower access to both extension and improved seed overall, this suggests that there may be opportunities for extension to more effectively support women farmers' seed access.

Previous literature suggests that agricultural extension access can aid in agricultural development (Ariga et al., 2019; AfranaaKwapong & Nkonya, 2015; Jones & Garforth, 1997; Eicher, 2007), but differential access may exacerbate inequities (Fisher et al., 2019; Ragasa, 2014). Thus, it does not seem that commitments for a more inclusive and equitable African Green Revolution will likely come to fruition if existing discrepancies in resource and information access

across women and men farmers are not addressed (Blaustein, 2008; Shilomboleni, 2017; Wise et al., 2020).

Although improved agricultural technologies from the formal seed sector can provide substantial benefits to crop productivity (Altalb et al., 2015), nutrition and food security outcomes (Toenniessen et al., 2008), and market participation (Scoones & Thompson, 2011), it is imperative to not assume that they will be equally accessible across all types of farmers. Given the historic marginalization that women farmers have experienced, better understanding their experiences in accessing information and resources from extension is critical. However, one important question that remains – and one that the findings from this study cannot answer – is what the preferences and priorities of female-headed households actually are. While these findings demonstrate that women have less access to both extension and improved crop varieties, they do not elucidate whether women desire better access to these improved varieties. While they very well may want the same opportunities and resources as male farmers receive, it is also possible that other programs developed and designed by extension would be appreciated. For example, because women farmers have been found to emphasize household and nutrition security to a greater degree than men farmers (Reynolds et al., 2020), it is possible that programming around kitchen gardens and cooking classes would be well-received. This is not to suggest that these types of programs are what extension services should do but to raise the possibility that (some) women farmers may prefer other forms of development aside from the model of high productivity that extension has historically promoted (Aremu et al., 2015; Blaustein, 2008; Shiloboleni, 2017). Therefore, it is necessary to determine whether agricultural extension needs to be more accessible to female-headed households and/or if it needs to adapt their programming to better fit the needs and priorities of women farmers (as articulated by women farmers themselves).

Despite the insight that our results provide, our study does have some limitations. First, given that our primary outcome variable is binary, we have only a partial understanding of access to extension (i.e., our data only provide a coarse measure of access and do not account for frequency of access, satisfaction with quality of service, etc.). Second, we have a limited ability to understand the full effects of the 2018 National Seed Policy. While the years of our data allow us to draw some inferences regarding the influence of this policy on seed sourcing behaviors of small-scale farmers, data to directly assess the influence of the policy do not exist in the LSMS data. We thus recommend future studies analyze the changes that the 2018 National Seed Policy induced with regard to farmer populations served (with explicit attention to gender), seed sourcing activities, and seed adoption. Additionally, future studies could further explore geographic location and household wealth; while we use proxies for wealth, wealth continues to be a variable of interest. The interactions between extension services and seed systems in Uganda are complex and multifaceted, as there are numerous organizations and institutions involved in bolstering agricultural production (Davis, 2008) and the recent passage of the National Seed Policy only adds to this complexity.

Our findings provide further evidence that women farmers rely on the informal seed sector more than men farmers, due in part to inequitable access to extension services. Given the current and ongoing challenges related to food security, gender discrepancies, and seed system development, research must continue to assess the gendered differences of extension access and formal – and informal - seed sector participation to better inform agricultural development strategies. Traditional extension models that assume - purposefully or not - that the dissemination of improved technologies is equally distributed across populations must be adapted to recognize the diversity of farmers' needs across genders and sub-populations. To fulfill its mission, and to

avoid repeating earlier pitfalls of providing programming biased towards certain types of farmers (i.e., men, specialized production, etc.), extension must consistently evaluate the content and audience of its programs, as well as the degree to which they are serving farmers that have historically been overlooked.

References

Adzawla, W., Azumah, S.B., Anani, P.Y., & Donkoh, S.A. (2019). Gender perspectives of climate change adaptation in two selected districts of Ghana. *Heliyon*, e02854.

AfranaaKwapong, N., & Nkonya, E. (2015). Agricultural extension reforms and development in Uganda. *Journal of Agricultural Extension and Rural Development, 7*(4), 122-134. https://doi.org/10.5897/JAERD2013.0528

Altalb, A. A. T., Filipek, T., & Skowron, P. (2015). The role of agricultural extension in the transfer and adoption of agricultural technologies. *Asian Journal of Agriculture and Food Sciences*, *03*(05), 500-507.

Aremu, P. A., Kolo, I. N., Gana, A. K., & Adelere, F. A. (2015). The crucial role of extension workers in agricultural technologies transfer and adoption. *Global Advanced Research Journal of Food Science and Technology*, *4*(2), 14–18.

Aremu, T., & Reynolds, T. W. (2024). Welfare benefits associated with access to agricultural extension services in Nigeria. *Food Security*, *16*, 295-320. https://doi.org/10.1007/s12571-023-01428-7

Ariga, J., Mabaya, E., Waithaka, M., & Wanzala-Mlobela, M. (2019). Can improved agricultural technologies spur a green revolution in Africa? A multicountry analysis of seed and fertilizer delivery systems. *Agricultural Economics*, *50*(S1), 63–74. https://doi.org/10.1111/agec.12533

Blaustein, R. J. (2008). The Green Revolution arrives in Africa. *BioScience*, *58*(1), 8–14. https://doi.org/10.1641/B580103

Bryan, E., Theis, S., Choufani J., De Pinto, A., Meinzen-Dick, R.S., Ringler, C. (2017). Gender-sensitive, climate-smart agriculture for improved nutrition in Africa south of the Sahara. In De Pinto, A., Ulimwengu, J (Eds.), *A thriving agricultural sector in a changing climate: Meeting Malabo Declaration goals through climate-smart agriculture*. (Chapter 9, pp. 114-135). Washington, D.C.: International Food Policy Research Institute (IFPRI). http://dx.doi.org/10.2499/9780896292949_09

Croft, M. M., Marshall, M. I., Odendo, M., Ndinya, C., Ondego, N. N., Obura, P., & Hallett, S. G. (2017). Formal and informal seed systems in Kenya: Supporting indigenous vegetable seed quality. *The Journal of Development Studies*, *54*(4), 758–775. https://doi.org/10.1080/00220388.2017.1308487

David, S. (2004). Farmer seed enterprises: A sustainable approach to seed delivery? *Agriculture and Human Values*, *21*, 387–397.

Davis, K. (2008). Extension in Sub-Saharan Africa: Overview and assessment of past and current models, and future prospects. *Journal of International Agricultural and Extension Education*, *15*(3), 15-28.

Dibba, L., Zeller, M., Diagne, A., & Nielsen, T. (2015). How accessibility to seeds affects the potential adoption of an improved rice variety: The case of The New Rice for Africa (NERICA) in The Gambia. *Quarterly Journal of International Agriculture, 4*(1), 38-50.

Eicher, C. (2007). Agricultural extension in Africa and Asia. *World Ag Info Project*. https://hdl.handle.net/1813/66573.

Fan, S., & Rue, C. (2020). The role of smallholder farms in a changing world. In S. Gomez y Paloma, L. Riesgo, & K. Louhichi (Eds.), *The role of smallholder farms in food and nutrition security* (pp. 13–28). Springer International Publishing. https://doi.org/10.1007/978-3-030-42148-9_2

FAO, IFAD, UNICEF, WFP, & WHO. (2019). *The state of food security and nutrition in the world 2019. Safeguarding against economic slowdowns and downturns.* Rome: FAO.

Fisher, M., & Carr, E. R. (2015). The influence of gendered roles and responsibilities on the adoption of technologies that mitigate drought risk: The case of drought-tolerant maize seed in eastern Uganda. *Global Environmental Change*, *35*, 82–92. https://doi.org/10F.1016/j.gloenvcha.2015.08.009

Fisher, M., Habte, Endeshaw, E., William, & Abate, Tsedeke, L., Paul. (2019). Reducing gender gaps in the awareness and uptake of drought-tolerant maize in Uganda: The role of education, extension services and social networks. *AgriGender*, *04*(01), 38–50. https://doi.org/10.19268/JGAFS.412019.4

Gengenbach, H., Schurman, R. A., Bassett, T. J., Munro, W. A., & Moseley, W. G. (2018). Limits of the New Green Revolution for Africa: Reconceptualizing gendered agricultural value chains. *The Geographical Journal*, *184*(2), 208–214. https://doi.org/10.1111/geoj.12233

Jones, G., & Garforth, C. (1997). The history, development, and future of agricultural extension. In B.E. Swanson, R.P Bentz, & A.J. Sofranko (eds)., *Improving agricultural extension: A reference manual* (Chapter 1). FAO: Rome. https://www.fao.org/4/w5830e/w5830e00.htm#Contents

Kansiime, M. K., Karanja, D. K., Alokit, C., & Ochieng, J. (2018). Derived demand for African indigenous vegetable seed: Implications for farmer-seed entrepreneurship development. *International Food and Agribusiness Management Review*, *21*(6), 723–739. https://doi.org/10.22434/IFAMR2017.0095

Kyohairwe, S. B., & Tibaijuka, B. (2013). Boundaries of community engagement in enhancing performance of government programs at the local level: A lesson drawing from National Agricultural Advisory Services (NAADS), Uganda. *African Journal of Governance and Development, 2*(1), 57-70.

Negin, J., Remans, R., Karuti, S., & Fanzo, J. C. (2009). Integrating a broader notion of food security and gender empowerment into the African Green Revolution. *Food Security*, *1*(3), 351–360. https://doi.org/10.1007/s12571-009-0025-z

Otieno, G. A., Reynolds, T. W., Karasapan, A., & Noriega, I. L. (2017). Implications of seed policies for on-farm agro-biodiversity in Ethiopia and Uganda. *Sustainable Agriculture Research*, *6*(4), 12-30. https://doi.org/10.5539/sar.v6n4p12

Otieno, G., Zebrowski, W. M., Recha, J., & Reynolds, T. W. (2021). Gender and social seed networks for climate change adaptation: Evidence from bean, finger millet, and sorghum seed systems in East Africa. *Sustainability, 13*(4), 2074. https://doi.org/10.3390/su13042074

Pan, Y., Smith, S. C., & Sulaiman, M. (2018). Agricultural extension and technology adoption for food security: Evidence from Uganda. *American Journal of Agricultural Economics*, *100*(4), 1012–1031. https://doi.org/10.1093/ajae/aay012

Parayil, G. (1992). The green revolution in India: A case study of technological change. *Technology and Culture*, *33*(4), 737-756.

Pray, C. (1981). The Green Revolution as a case study in transfer of technology. The *Annals of the American Academy of Political and Social Science, 458*(1), 68-80.

Puskur, R., Mudege, N. N., Njuguna-Mungai, E., Nchanji, E., Vernooy, R., Galiè, A., & Najjar, D. (2021). Moving beyond reaching women in seed systems development. In R. Pyburn & A. van Eerdewij (Eds.), *Advancing gender equality through agricultural and environmental research: Past, present, and future* (pp. 113-145). Washington, DC: International Food Policy Research Institute. https://doi.org/10.2499/9780896293915_03.

Quisumbing, A.R., & Pandolfelli, L. (2010). Promising approaches to address the needs of poor female farmers: Resources, constraints, and interventions. *World Development*, *38*(4), 581–592. https://doi.org/10.1016/j.worlddev.2009.10.006

Quisumbing, A.R., Meinzen-Dick, R., Raney, T.L., Croppenstedt, A., Behrman, J.A. & Peterman, A. (2014). Closing the knowledge gap on gender in agriculture. In A.R. Quisumbing, R. Meinzen-Dick, T.L.Raney, A. Croppenstedt, J.A. Berhman, & A. Peterman (Eds.), *Gender in agriculture: Closing the knowledge gap* (3-27). Springer Dordrecht.

Ragasa, C. (2014). Improving gender responsiveness of agricultural extension. In A.R. Quisumbing, R. Meinzen-Dick, T.L.Raney, A. Croppenstedt, J.A. Berhman, & A.

Peterman (Eds.), *Gender in agriculture: Closing the knowledge gap* (411-430). Springer Dordrecht.

Reynolds, T., Tobin, D., Otieno, G., McCracken, A., & Guo, J. (2020). Differences in crop selection, resource constraints, and crop use values among female- and male-headed smallholder households in Kenya, Tanzania, and Uganda. *Journal of Agriculture, Food Systems, and Community Development*, 9(4): 65-92. https://doi.org/10.5304/jafscd.2020.094.011

Rwamigisa, P. B., Birner, R., Mangheni, M. N., & Semana, A. (2018). How to promote institutional reforms in the agricultural sector? A case study of Uganda's National Agricultural Advisory Services (NAADS). *Development Policy Review*, *36*(5), 607–627. https://doi.org/10.1111/dpr.12318

Scoones, I., & Thompson, J. (2011). The politics of seed in Africa's Green Revolution: Alternative narratives and competing pathways. *IDS Bulletin*, *42*(4), 1–23. https://doi.org/10.1111/j.1759-5436.2011.00232.x

Semana, A.R., 2008. Agricultural extension services at crossroads: Present dilemma and possible solutions for future in Uganda. Mimeo. Department of Agricultural Extension and Education, Makerere University, Kampala, Uganda. Print.

Shikuku, K. M., Pieters, J., Bulte, E., & Läderach, P. (2019). Incentives and the diffusion of agricultural knowledge: Experimental evidence from Northern Uganda. *American Journal of Agricultural Economics*, *101*(4), 1164–1180. https://doi.org/10.1093/ajae/aaz010

Shilomboleni, H. (2017). A sustainability assessment framework for the African Green Revolution and food sovereignty models in southern Africa. *Cogent Food & Agriculture*, *3*(1), 1328150. https://doi.org/10.1080/23311932.2017.1328150

Simtowe, F., Marenya, P., Amondo, E., Worku, M., Rahut, D. B., & Erenstein, O. (2019). Heterogeneous seed access and information exposure: Implications for the adoption of drought-tolerant maize varieties in Uganda. *Agricultural and Food Economics*, *7*(1), 15. https://doi.org/10.1186/s40100-019-0135-7

Sperling, L., & Cooper, H. (2004). *Understanding seed systems and strengthening seed security*. In L. Sperling, T. Osborn, & D. Cooper (Eds.), *Towards effective and sustainable relief activities* (pp. 7-33). Rome: FAO. Plant Production and Protection Paper 181.

Toenniessen, G., Adesina, A., & DeVries, J. (2008). Building an Alliance for a Green Revolution in Africa. *Annals of the New York Academy of Sciences*, *1136*(1), 233–242. https://doi.org/10.1196/annals.1425.028

Wattnem, T. (2016). Seed laws, certification and standardization: Outlawing informal seed systems in the Global South. *The Journal of Peasant Studies*, *43*(4), 850–867.

https://doi.org/10.1080/03066150.2015.1130702

Wise, T. A. (2020). *Failing Africa's farmers: An impact assessment of the Alliance for a Green Revolution in Africa*. Tufts University. Global Development and Environment Institute Working Paper No. 20-01. https://sites.tufts.edu/gdae/files/2020/07/20-01_Wise_FailureToYield.pdf

Witinok-Huber, R., Radil, S., Sarathchandra, D., & Nyaplue-Daywhea, C. (2021). Gender, place, and agricultural extension: A mixed-methods approach to understand farmer needs in Liberia. *The Journal of Agricultural Education and Extension*, *27*(4), 553–572. https://doi.org/10.1080/1389224X.2021.1880453

World Bank. (2007). *World development report 2008: Agriculture for development.* Washington, DC: World Bank. https://openknowledge.worldbank.org/handle/10986/5990

World Bank. (2015). Enabling the business of agriculture 2015: Progress report. Washington, DC: World Bank. https://eba.worldbank.org/en/reports/2015.