Gender gaps in sorghum productivity: evidence from male- and female-managed plots in Uganda

Article *in* Development in Practice · June 2022

DOI: 10.1080/09614524.2022.2069228

Routledge
Taylor & Francis Group

Development in Practice

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/cdip20

Gender gaps in sorghum productivity: evidence from male- and female-managed plots in Uganda

Philip Miriti, David Jakinda Otieno, Evans Chimoita, Edward Bikketi, Esther Njuguna & Chris O. Ojiewo

To cite this article: Philip Miriti, David Jakinda Otieno, Evans Chimoita, Edward Bikketi, Esther Njuguna & Chris O. Ojiewo (2022): Gender gaps in sorghum productivity: evidence from male- and female-managed plots in Uganda, Development in Practice, DOI: 10.1080/09614524.2022.2069228

To link to this article: https://doi.org/10.1080/09614524.2022.2069228

Published online: 01 Jun 2022.

DEVELOPMENT IN PRACTICE
https://doi.org/10.1080/09614524.2022.2069228

Gender gaps in sorghum productivity: evidence from male- and female-managed plots in Uganda

Philip Miriti, David Jakinda Otieno, Evans Chimoita, Edward Bikketi, Esther Njuguna, and Chris O. Ojiewo

ABSTRACT
Gender gaps in crop productivity can negatively affect rural socio-economic development of agrarian economies with serious implications for food and nutrition security. We assess productivity in male- and female-managed sorghum plots in Lira, Kumi, and Serere districts in Uganda. We find male-managed plots have higher productivity of 850.6 kgs/ha compared to female-managed plots (832.6 kgs/ha). An observed mean gender gap of 18% due to structural advantages of male plots (57%), structural disadvantages of female plots (33%), and endowment (10%) exists. Therefore, interventions aimed at promoting equitable access to institutional support services are paramount in reducing structural disadvantages against female farmers.

ARTICLE HISTORY
Received 15 July 2021
Accepted 19 April 2022

KEYWORDS
Gender yield gaps; plot manager; sorghum; agricultural productivity; Oaxaca–Blinder decomposition

1. Introduction

Agricultural productivity plays an important role in promoting welfare and stimulating growth in on-farm and non-farm activities of rural households. Specifically, sorghum (*Sorghum bicolor)* contributes approximately half of the micronutrient requirements of small-holder farmers living within the semi-arid tropics of Africa and Asia; it is therefore a key crop in promoting food and nutrition security (Kumar et al. 2018). Sorghum is a drought-tolerant cereal crop that is mainly grown in the semi-arid tropics. In Africa, it is the second staple grain crop after maize (Mundia et al. 2019) and is mainly cultivated for food and fodder, especially by smallholder farmers in drylands that are characterised by low soil fertility, inadequate extension services, and erratic rainfall (Assefa et al. 2020).

In Uganda, sorghum is an important dryland cereal after maize and wheat in terms of total production (Wang et al. 2015). Uganda supplies approximately 0.5% of the world's sorghum output (USDA 2018). It is the staple crop for a majority of people in the Northern and Eastern parts where it is primarily grown. Farmers in these areas exhibit low levels of input use; hence, productivity over the years has remained relatively low and the sorghum value chain greatly remains under-developed (Nangobi and Mugonola 2018; Tenywa et al. 2018).

Various studies have documented the existence of gender disparities in agricultural production in sub-Saharan Africa (SSA) due to the patriarchal kinship structures where men tend to have stronger rights to assets, especially land ownership, thus skewing power relations between spouses (Sell and Minot 2018; Danso-Abbeam, Baiyegunhi, and Ojo 2020; Gebre et al. 2021). This leads to men having a higher power in household decision-making in access, utilisation of assets and control of income generated from economic activities, hence lowering women's bargaining power (Osanya et al. 2020).

Differences in productivity across plot managers, which refers to the person involved in making day-to-day farming decisions on a plot have been attributed to gender-specific constraints in access to farm inputs leading to lower and unequal levels of fertiliser, labour, and land use (Palacios-Lopez

CONTACT Philip Miriti miritiphilip@gmail.com

and Lopez 2015; Khan et al. 2021). Access to institutional support services, such as information and credit facilities, by female plot managers is limited compared to male-managed plots (Sell et al. 2018). In addition, female plot managers in SSA have more limited access and weak tenure security over land than male farmers (Chigbu, Paradza, and Dachaga 2019). However, where there is joint plot management, these constraints have been addressed to some extent due to the complementary role played by men (Miriti et al. 2021).

The majority of studies on gender gaps in productivity use the household head as a proxy to estimate plot-level outcomes rather than the plot manager who is directly involved in the plot activities (Kilic, Palacios-López, and Goldstein 2015; Mukasa and Salami 2016; Mugisha et al. 2019). There is a likelihood that the household head is not the person responsible for making farm-level decisions. Therefore, associating the household head with farm productivity may lead to inaccurate productivity measurements (Kilic, Palacios-López, and Goldstein 2015). The present study attempts to address this knowledge gap by using plot manager to reduce the gender gap.

We provide rigorous evidence on gender gaps in productivity between male- and female-managed sorghum plots using the Oaxaca–Blinder decomposition approach by taking into account observable and unobservable factors, examining productivity differences and their determinants in Uganda. The rest of the paper is organised as follows. Section 2 comprises the methodology highlighting the study area, sampling, and the empirical analysis. Section 3 presents the results and discussions while Section 4 provides the conclusion and policy implications.

2. Methodology

2.1. Description of the study area

The study was undertaken in the Lira, Serere, and Kumi districts of Uganda, which are the predominant sorghum producing areas (Figure 1).

Lira district lies in the Northern part of Uganda at a latitude of 2.2316° N and a longitude of 32.9438° E. The district receives about 1300 mm of rainfall annually and approximately 71% of its residents depend on subsistence farming for their livelihood (UBOS 2017a). Serere district lies at a latitude of 1.4994° N and a longitude of 33.5490° E in Eastern Uganda. In the 2012 national population census, the district had a population of approximately 294,100. The district receives an average of 1250 mm rainfall annually, and has an annual mean temperature of 25° C (UBOS 2017b). Kumi district is located in the Eastern region of Uganda at a latitude of 1.4877° N and a longitude of 33.9304° E and has a population of about 255,500. The district receives an average of about 900 mm rainfall, and has a mean annual temperature of 24° C (UBOS 2017c).

2.2. Data sources and sampling

The study used plot-level gender-disaggregated data collected by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). A multi-stage sampling procedure was used to identify study areas and respondents. In the first stage, the Kumi, Lira, and Serere districts were selected purposively because they predominantly produce sorghum for food security and commercial purposes. In the second stage, four sub-counties within the districts with the highest sorghum production were selected: Amach and Agali sub-counties in Lira, Katete in Kumi, and Mukongoro in Serere. In the third stage, a systematic random sampling procedure was used to select respondents within the four sub-counties who were then interviewed using structured questionnaires. A total sample of 362 (182 male plot managers and 180 female plot managers) were interviewed – 47% from Lira, 31% from Serere, and the rest from Kumi district – which were allocated proportionately to their population sizes. The necessary ethical approvals were obtained before the study commenced from the Institutional Ethics Committee (IEC) at ICRISAT and informed consent from all farmers was sought before the interview process.

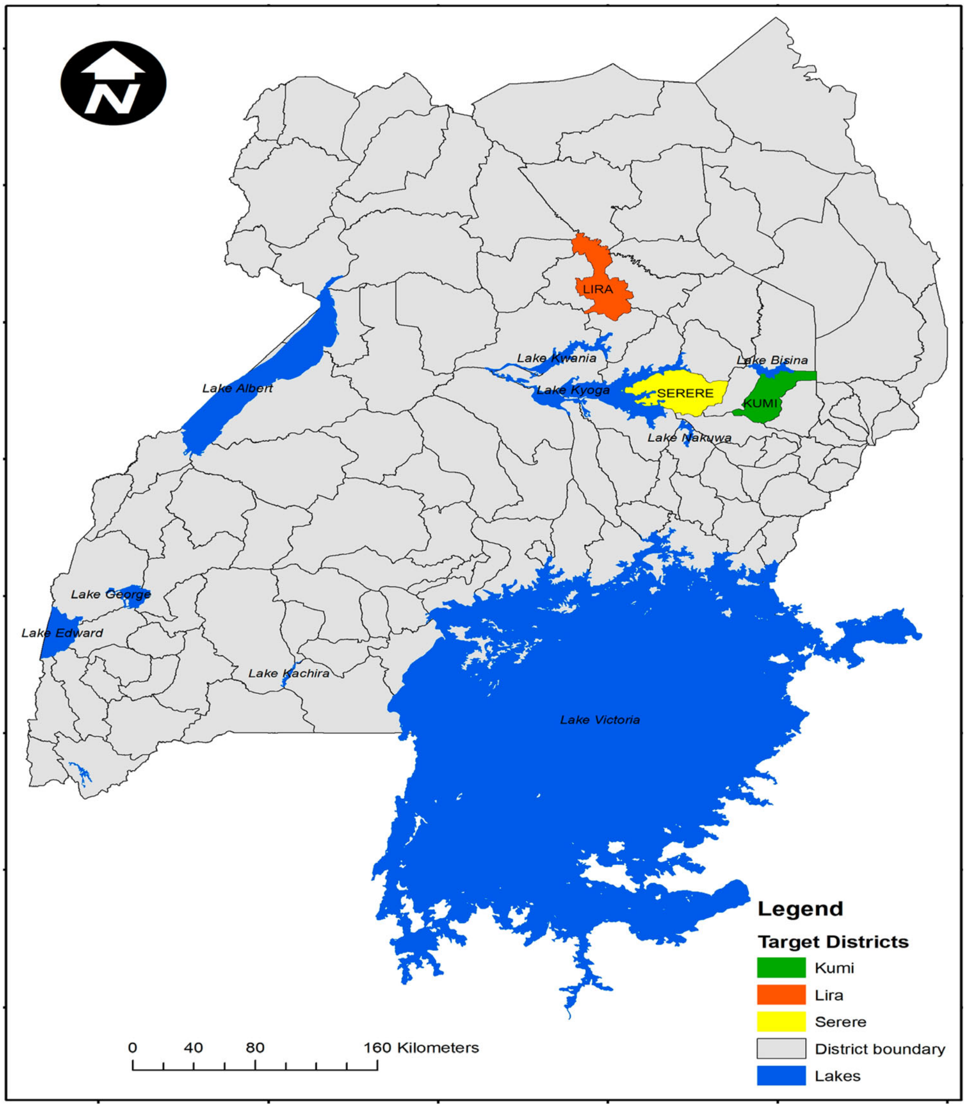

Figure 1. A map of Uganda showing the study sites. Source: Adapted from UBOS (2016).

2.3. Empirical analysis

The data collected was downloaded from the Open Data Kit (ODK) and analysed using Stata 15 to obtain frequencies, mean, standard deviations of socio-economic characteristics, and estimation of determinants of sorghum farmers. Productivity estimates for male and female managed plots were estimated following the partial factor productivity (PFP) equation as follows:

$$PFP_{ai} = \frac{Y_a}{X_{ai}} \quad (1)$$

where PFP_{ai} denotes the partial factor productivity of plot a under plot manager *a*, Y_a is the output (sorghum yield in kilograms) from plot *a*, while X_{ai} is the primary input (land in hectares) used for plot *a* by the plot manager *i*. Since the dependent variable is continuous in nature, the Ordinary least square (OLS) regression was fitted to evaluate determinants of sorghum productivity following

Udry et al. (1995), who expressed a simple productivity function as:

$$Y_{ai} = \alpha X_{ai} + vG_{ai} + \mu_{ai} \tag{2}$$

where Y_{ai} = sorghum productivity (kgs/ha) of plot a under manager i; X_{ai} denotes variables used, such as age, years of formal schooling completed, years of sorghum farming experience, household size, distance to plot from homestead, amount of seed used, hired labour, family labour, access to credit, access to extension services and farmer group membership; G_{ai} is a dummy variable denoting the gender of the plot a; and μ_{ai} is the error term.

The approach of estimating determinants discussed in Equation 2 does not give insights on relative contribution of the vectors of covariates to the gender productivity gap (Joe-Nkamuke et al. 2019). In order to account for this, we adopt the Oaxaca–Blinder decomposition approach (Oaxaca 1973; Djurdjevic and Radyakin 2007). The decomposition technique is increasingly being applied in gender and productivity studies (see for example, Kilic, Palacios-López, and Goldstein 2015; Bello et al. 2021; Nchanji et al. 2021; Singbo et al. 2021). The approach starts by estimating the expected yield value per ha for the male (m) and female (f) plot managers as presented in Equation 3:

$$E(Y_g) = \alpha_g + E(X_g)^{'}\beta_{g'} \tag{3}$$

where g denotes the gender of the plot manager, α is the intercept, β is the slope coefficient, and X denotes independent variables. The gender gap in mean productivity between the male- and female-managed plots is expressed as follows:

$$Gender\ gap = E\ (y_m) - E\ (y_f) = \sigma_m + E\ (X_m)^{'}\beta_m - \ \sigma_f - E(X_f)^{'}\beta_f \tag{4}$$

The gap in the equation above can further be decomposed into two parts, where the first part is composed of the gender gap that is explained by the male and female differences, and the second part consists of the unexplained part (Oaxaca 2007). Therefore, it can be expressed as:

$$Gender\ gap = Q + U \tag{5}$$

where Q denotes the gender gap due to the differences between the male and female plot managers and can be expressed as:

$$Q = [E(X_m)^{'} - E(X_f)']\beta^* \tag{6}$$

where β^* represents the non-discriminatory coefficients. The second part of Equation 5 is referred to as the unexplained U or the structural effect and it accounts for the differences in returns or the discrimination between the male and female plot managers. Following Fortin, Lemieux, and Firpo (2010), it can be expressed as follows.

$$U = (\alpha_m - \alpha) + [E(X_m)^{'}(\beta_m - \beta^*)] + (\alpha - \alpha_f) + \ [E\ (X_f)^{'}(\beta^* - \beta_f)] \tag{7}$$

Equation 7 can be subdivided further into two components:

$$U_m = (\alpha_m - \alpha) + [E(X_m)^{'}(\beta_m - \beta^*)] \tag{8a}$$

and

$$U_f \ = \ (\alpha - \alpha_f) + \ [E\ (X_f)^{'}(\beta^* - \beta_f)] \tag{8b}$$

where Equation 8a represents the discrimination in favour of the structural advantage of the male managed plots and Equation 8b denotes the discrimination or the structural disadvantage of the female managed plots (Oaxaca 2007; Fortin, Lemieux, and Firpo 2010).

3. Results and discussion

3.1. Socio-economic characteristics of the respondents

Table 1 shows the summary statistics of the interviewed plot managers. The majority of sorghum plot managers were adults with less than seven years of formal education although male plot managers had a relatively higher number of years spent in school. This shows that rural sorghum farmers in Uganda have little formal human capital.

The average years of sorghum production for the plot managers were more than ten years for the two groups, showing that the majority of the farmers have been growing sorghum for quite a long time. The World Bank (2018) similarly noted that in Uganda, about 70% of households rely on agriculture as a source of livelihood. The mean household size for the male- and female-managed plots is slightly above the national mean household size of 4.7 persons, which has remained relatively stable in the last decade (UBOS 2016). This variance from the national household means can be explained by the polygamous nature of rural households where the study sites are located.

The mean plot size of sorghum farmers is less than two hectares, implying that they are smallholder farmers. This is consistent with Cervantes-Godoy (2015) who defined smallholder farmers as those owning less than two hectares of land. However, the average plot size in the three study areas is below the national average farm size of 0.97 ha (Priegnitz et al. 2019). This can be attributed to the subdivision of agricultural land due to rapid population growth and its attendant pressure on productive resources, such as arable land.

Distance to the plot from the homestead was larger for male plot managers; this could be attributed to the likelihood of farmers leasing land from various areas to increase profit margins. For farm inputs such as hired labour, family labour, and the amount of seed and fertiliser used, male plot managers had higher quantities compared to female plot managers. This corroborates Palacios-Lopez, Christiaensen, and Kilic (2017) who observed that female plot managers have lower access to and utilisation of farm inputs. We observe a similar pattern for access to credit facilities, access to extension services, and farmer group membership. Lastly, the age of the plot manager, years completed in school, household size, plot size, farmer group membership, and access to credit were significantly different between the two groups.

3.4. Measurement of sorghum productivity

Sorghum productivity was computed using plot-level data on the male-managed plots, the female-managed plots, and the pooled sample. Male plot managers had the highest productivity (850.6 kgs/

Table 1. Summary characteristics by gender of the plot managers and statistical difference.

	Male plot managers		Female plot managers		Statistical differences
Variable	Mean	SD	Mean	SD	(*p*-value)*
Age of the plot manager	46.40	15.64	43.82	14.05	**0.056**
Years of formal schooling	6.19	5.20	4.24	3.26	**0.000**
Household size	5.93	3.22	7.17	2.95	**0.000**
Years of sorghum farming	13.20	13.31	12.63	10.23	0.300
Average distance to the plot (metres)	583.25	1016.83	505.40	987.64	0.346
Plot size (mean ha)	0.86	0.25	0.27	0.25	**0.055**
Family labour (mean person hours)	32.95	13.36	30.69	11.90	0.281
Hired labour (mean person hours)	6.29	8.55	4.41	8.65	0.862
Average quantity of seed used (Kgs)	11.72	19.71	10.25	12.24	0.866
Average amount of fertiliser used (Kgs)	0.04	0.57	0.00	0.00	0.179
Farmer group membership (% yes)	55.13		40.31		**0.080**
Access to credit (% yes)	47.42		30.10		**0.055**
Access to agricultural extension (% yes)	48.60		44.90		0.266

Note: SD is standard deviation, *pairwise comparisons done using Bonferroni test
Source: Survey Data (2017).

ha) compared to the female managed plots (832.6 kgs/ha) and the pooled sample (841.6 kgs/ha). This finding is similar to Djurfeldt et al. (2019); (Miriti et al. 2021), and Singbo et al. (2021), who attributed it to male plot managers' superior access to productive resources and institutional support services. The productivity of the male-managed plots, the female-managed plots, and the pooled sample is presented through a kernel density plot in Figure 2.

Further, Peterman et al. (2011) noted that female farmers have lower human capital, resource bases, access to, and utilisation of farm inputs than male farmers, hence they have low ability to respond to subsidy programmes and agricultural incentives, thus leading to low productivity. Moreover, female plot managers spend more time on domestic chores than male plot managers, as well as taking disproportionate responsibility of care for their children, thus limiting the time they spend on their plots (Donald et al. 2018). Consequently, this impacts negatively on the productivity of their sorghum plots.

3.5. Determinants of sorghum productivity

Results show that years of formal learning positively influences sorghum productivity for female managed sorghum plots (Table 2). Formal education plays a crucial role in decision making, especially in the use of better inputs. This corroborates findings by Wouterse and Badiane (2019) that investment in human capital, such as education, stimulates productivity. Similarly, the age of the plot manager is positive and significant for the female plot manager. Therefore, a one unit increase in the age of a female plot manager would lead to a 9% increase in productivity, which can be attributed to the possibility that older female plot managers may have a higher access to productive resources and institutional support services than younger women (Ingutia and Sumelius 2022).

However, household size has a negative and significant effect on sorghum productivity for the female-managed plots. Rural sorghum farmers are resource-poor and tend to have large household sizes. This corroborates the socio-demographic characteristics in Table 1, where the mean household

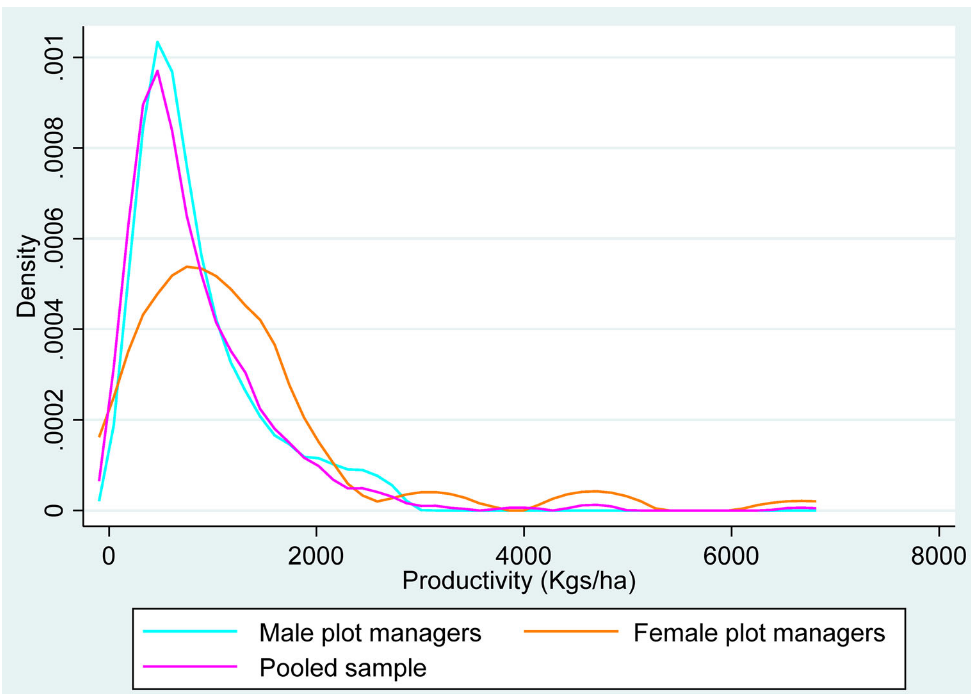

Figure 2. Gendered distribution of sorghum productivity in Uganda at plot level. Source: Survey data (2017).

Table 2. Determinants of sorghum productivity by gender of the plot manager.

Variables	Male Managed plots		Female managed plots		Pooled sample	
	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Age of the plot manager	0.019	0.063	0.091*	0.047	0.071*	0.041
Years completed in school	0.046	0.071	0.127**	0.056	0.080*	0.047
Household size	−0.083	0.109	−0.215***	0.078	−0.139**	0.069
Years of sorghum farming	−0.030	0.064	−0.086	0.056	−0.057	0.044
Average distance to the plot (metres)	0.010	0.027	0.0003	0.022	0.005	0.018
Family labour (person hours)	0.211***	0.051	0.104**	0.041	0.168***	0.034
Hired labour (person hours)	0.092***	0.033	0.150***	0.025	0.131***	0.021
Amount of seed (kgs)	0.017***	0.004	0.0002	0.003	0.008***	0.002
Plot size (mean ha)	−2.423***	0.508	−0.874***	0.296	−1.443***	0.283
Farmer group membership (1 = Yes)	−0.002	0.121	0.096	0.097	0.003	0.081
Access to credit (1 = Yes)	0.016	0.137	−0.010	0.100	−0.007	0.087
Access to agricultural extension (1 = Yes)	−0.253**	0.119	0.155*	0.089	−0.076	0.076
Constant	6.53***	0.637	5.893***	0.452	5.936***	0.393
Adjusted R-squared	0.3487		0.2579		0.2251	

***, ** and * denote statistical significance at 1%, 5%, and 10% levels, respectively.
Source: Survey Data (2017).

size was higher than the national average. This increases expenses on food and health services for the household, thus limiting resources available to invest in farm inputs. As noted by Mango et al. (2015), this results in low technical efficiency, thus lowering productivity.

Interestingly, the coefficients for labour (both family and hired) were positive and significant for the male-managed plots, female-managed plots, and the pooled sample. However, the amount of seed used was positive and significant for the male-managed plots and the pooled sample. Similar results were observed by Kloss and Petrick (2018) and Anang et al. (2022), who argued that proper utilisation of farm inputs enhances crop productivity.

There was a significant inverse relationship between plot size and sorghum productivity for all categories of plot managers; the largest decline is in male-managed plots (−2.42). Empirical evidence has shown that small farms are more manageable, thus increasing efficiency in utilisation of farm inputs as well as close monitoring of farm activities. These results are consistent with Muyanga and Jayne (2019) and Sheng, Ding, and Huang (2019), who found that productivity tends to decline as the farm size increases.

Access to extension had a negative and significant effect on sorghum productivity for female-managed sorghum plots. This shows that male plot managers who had extension services were less productive than those who did not. This could be explained by three possibilities: improper application of the services by the plot managers, the extension service provided was not specific to sorghum growing, or the services were not suitable for the local agro-ecological condition. This finding corroborates Abate, Dessie, and Mekie (2019). On the other hand, Mwololo et al. (2019) and Rajkhowa and Qaim (2021) argue that access to extension plays a critical role in farmers' ability to diversify farming enterprises, which leads to increased productivity.

3.6. Oaxaca–Blinder decomposition of the gender agricultural productivity gap

As noted in Section 2.3, the application of OLS in gender and productivity studies does not account for the contribution of the explanatory variables to the gender gap. Table 3 presents the decomposition estimates on the differential in the log of the productivity value between male and female sorghum plot managers. The Oaxaca–Blinder decomposition in terms of endowment and structural effects offers detailed insights into the magnitude of the contribution of observable factors to the gender gap.

The estimates are grouped in three parts; the first part (mean gender differential) presents the observed mean gender gap in productivity of 18.3%. This shows that, on average, sorghum plot

Table 3. Oaxaca decomposition of log value of sorghum productivity per hectare.

Mean Gender differential	Coefficient	Standard error				
Mean male-managed plot productivity	6.538***	0.048				
Mean female-managed plot productivity	6.354***	0.065				
Mean gender differential in productivity	0.183**	0.081				
Aggregate decomposition	Endowment effect		Male structural advantage		Female structural disadvantage	
			Coefficient	Standard Error	Coefficient	Standard Error
Total	0.047**	0.020	0.259***	0.042	0.148**	0.075
Share of the gender differential (%)	10		57		33	
Detailed decomposition	Endowment effect		Male structural advantage		Female structural disadvantage	
Age of the plot manager	0.002	0.006	0.017*	0.009	0.475	0.478
Years completed in school	−0.003	0.006	−0.005	0.008	0.124	0.133
Household size	0.001	0.005	−0.028***	0.011	−0.23	0.233
Years of sorghum farming	−0.034*	0.019	−0.007	0.008	−0.118	0.159
Average distance to the plot (metres)	0.0004	0.003	0.0003	0.002	−0.048	0.176
Family labour (person hours)	−0.040**	0.018	0.03	0.021	−0.594*	0.340
Hired labour (person hours)	0.039*	0.022	0.054**	0.025	0.100	0.062
Amount of seed (kgs)	0.059**	0.030	0.001	0.014	−0.184***	0.049
Plot size (mean ha)	−0.051	0.036	−0.031	0.022	1.031***	0.382
Farmer group membership (1 = Yes)	0.041*	0.022	0.022**	0.011	0.037	0.056
Access to credit (1 = Yes)	0.098***	0.017	−0.020***	0.011	−0.005	0.052
Access to agricultural extension (1 = Yes)	−0.032	0.020	−0.012	0.002	0.195***	0.066

***, ** and * denote statistical significance at 1%, 5%, and 10% levels, respectively.
Source: Survey Data (2017)

managers are 18.3% significantly more productive compared to female-managed plots. The second part consists of the aggregate decomposition in terms of the endowment effect which accounts for the gender gap in terms of socio-demographic differences between male and female plot managers and also includes the structural advantages and disadvantages. The aggregate endowment significantly accounts for 4.7% of the observed gender gap between the male and female plot managers and it explains 10% of the mean gender productivity differential. Likewise, the male structural advantage and female structural disadvantage significantly explain the mean gender productivity differentials of 57% and 33%, respectively. Similar findings were reported by Kilic, Palacios-López, and Goldstein (2015); Joe-Nkamuke et al. (2019); and Singbo et al. (2021).

The third part (detailed decomposition) captures the magnitude of contribution or reduction of the gender gap in productivity where a positive coefficient increases the gender gap while a negative coefficient reduces the disparity (Nchanji et al. 2021). The amount of seed, hired labour, access to credit, and farmer group membership contributes positively to the endowment effect, thereby exacerbating the gender gap in sorghum productivity between the male- and female-managed plots. On the other hand, years of farming sorghum and use of family labour reduce the endowment effect; therefore, it reduces the gender gap.

The age of male plot managers, hired labour, and membership of farmer groups contributes positively to the male structural advantages, which, in turn, act as positive contributors to the gender gap, while the household size and access to credit play a role in reducing the gender productivity gap. Similar findings were reported in Malawi by Nsanja, Kaluwa, and Masanjala (2021). On other hand, the amount of seed and use of family labour reduce the structural disadvantage of female plot managers, thus reducing the gender gap, while we find that access to extension services and the plot size increase the gender gap.

Generally, the main driver of the gender gap in sorghum production is the structural advantage of men (57%) which corroborates Addai, Ng'ombe, and Temoso (2022), who reported that gender gaps in Ghana are significantly attributed to men's structural advantages. However, our results differ from those of Joe-Nkamuke et al. (2019), who found that a 76% gender gap in Malawi was due to the endowment effect. Singbo et al. (2021) reported that the main driver of the gender gap remained unexplained (56%) by the structural disadvantage of women in Mali. Therefore, drivers of gender gaps in productivity vary from one context to another.

4. Conclusions and policy implications

This study assessed productivity differentials between male- and female-managed sorghum plots in Uganda. An Oaxaca –Blinder decomposition technique was applied to quantify the magnitude of the gender productivity differentials. Overall, the male-managed plots were found to be more productive than the female-managed plots. The amount of seed, family, and hired labour had significant positive effects on the productivity of male-managed sorghum plots. Age, access to extension, family, and hired labour positively influenced the productivity of female-managed plots. On average, male-managed plots are 18% more productive than female-managed plots. About 57% of the gender differential in productivity is accounted for by the male structural advantages. Access to extension services, access to credit, and the amount of hired labour are the most important factors that constitute the endowment effect. These findings offer novel insights for enhancing equity and progressive development through the empowerment of female plot managers. Due to the relative contribution of access to extension services to the gender gap, the government should put in place systems that promote efficient dissemination of extension services, especially to female plot managers. Private agricultural companies and non-governmental organisations that are involved in the provision of extension services should offer gender-inclusive and tailor-made services to farmers. For example, women farmers require a specialised agricultural extension that can help ease the double role they play as household caregivers and as farmers to improve the participation of female farmers and increase access and utilisation of farm inputs.

Access to agricultural credit by female plot managers can be facilitated by the legislature through the formulation of banking rules that favour female farmers. For instance, offering flexible repayment terms, lower interest rates, and credit facilities that are demand-driven and use of other forms of collateral besides land, such as women's group guarantees, can help increase uptake of financial products by female plot managers.

Female structural disadvantages, such as the size of plot owned and access to extension services by female plot managers, are greatly influenced by cultural and social norms; these calls for continued behavioural research on gender dynamics to promote the dissemination of information and interventions aimed at showcasing the importance of enhancing women's land rights and access to institutional support services, such as agricultural extension.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

This work was supported by the Bill and Melinda Gates Foundation [Grant No OPP1198373].

Notes on contributors

Philip Miriti is an Agricultural Economist and a research officer in the Sustainable Livestock Systems program (SLS), International Livestock Research Institute (ILRI), Nairobi, Kenya. He previously worked at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) on several projects such as Harnessing Opportunities for Productivity Enhancement (HOPE II) project and The Accelerated Varietal Improvement and Seed Delivery of Legumes and Cereals in Africa (AVISA) among other projects in Kenya, Ethiopia, Tanzania, and Uganda. Miriti holds a Collaborative Master of Science in Agricultural and Applied Economics (CMAAE) and a bachelor's degree in Agribusiness Management from the University of Nairobi, Kenya.

Dr. David Jakinda Otieno is an Agricultural Economist and Senior Lecturer in the Department of Agricultural Economics, University of Nairobi. His research interests include Consumer Preference Analysis, Agricultural Marketing/Commercialization, Analysis of Land Leasing, Economics of Climate Change, Livelihood Diversification, Value Chain Analysis, Agribusiness Development, Participatory Research Methods and Policy Analysis.

Dr. Evans Chimoita is an Agricultural Extension and community development expert and a Lecturer in the Department of Agricultural Economics, University of Nairobi, Kenya. Evans is an Alumni of University of Nairobi where he earned PhD in Agricultural Information and Communication Management. He also holds Bsc. and Msc. degrees in Agricultural Education and Extension. He has published and supervised both undergraduates and postgraduate students. He has vast knowledge and consultancy experience in several community development and extension projects including world bank-based Kenya Climate Smart Agriculture Project (KCSAP), Agricultural Sector Development and Support Programme II, European Union Horizon FoodLAND project, TMEA-UNES cross border food safety manuals and guidelines development project among other consultancies. Chimoita has been mentored by ILRI-AgriFoSe 2030 and Kenya Policy Briefs Vision 2030 programmes on research and development of policy briefs. He has passion for innovative software development on applications supporting socio-economic research and output, artificial intelligence innovations promoting transformation of agricultural value chains, new approaches in agricultural Extension enhancing community development such as participatory research methods, farmer research networks (FRN) and farmer field schools (FFS).

Dr. Edward Bikketi is a Research Scientist & Consultant with over 17 years' experience gender and social research with comprehensive experience in designing and implementing social science and inclusivity research projects for sustainable development, using Mixed methods (Q-squared studies), participatory and social learning approaches that facilitate gender - responsive and transformative approaches for empowerment of youth and women in agricultural development. Currently work with Microsave Consulting, Leading Private Sector Development in Digitizing Agriculture.

Esther Njuguna is a Senior Social Scientist working as a Gender Specialist at the International Livestock Research Institute, Nairobi, Kenya. Her research interests include gender dynamics in livestock feeds and forages, women's participation in agricultural food systems, and the interface between gender and technology use that leads to the transformation of norms and empowerment of women and the youth. She has been working with male and female smallholder farmers since 1996. She is a graduate of Wageningen University and Research Centre (Agricultural Development - MSc) and the University of Nairobi-(Agricultural Development and Economics) – PhD.

Dr. Chris O. Ojiewo is a Strategic Partnerships and Seed Systems Lead at CIMMYT and Co-PI of a multidisciplinary multi-stakeholder, multidoor project on developing and delivering high yielding, nutrient dense, climate-smart, market-preferred varieties of grain legumes and dryland cereals. His research aims to enhance varietal turnover to mitigate losses from evolving climate patterns, especially in dry areas with the poorest of the poor farmers, while addressing pest and disease complexes, and enabling public-private partnerships for enhanced seed delivery. Core to his sense of purpose is: improving productivity and profitability for smallholder farmers; gender equity; youth empowerment; nutrition security; knowledge sharing; and solving the perpetual problem of food, nutrition and income insecurity of the less privileged in developing countries. He works to establish a robust system that ensures sustainable, timely availability of and access to quality seed of dryland cereals and grain legumes at affordable prices through the participation of multiple stakeholders along the seed value chain. He is committed to gender equity as a guiding principle, considering the critical role women play in choosing legume and cereal varieties and seed sources.

ORCID

Philip Miriti http://orcid.org/0000-0002-3756-0736
Chris O. Ojiewo http://orcid.org/0000-0002-2885-9381

References

Abate, Tadie Mirie, Abebe Birara Dessie, and Taye Melese Mekie. 2019. "Technical Efficiency of Smallholder Farmers in Red Pepper Production in North Gondar Zone Amhara Regional State, Ethiopia." *Journal of Economic Structures* 8 (1): 18–32.

Addai, Kwabena Nyarko, John N. Ng'ombe, and Omphile Temoso. 2022. "Food Poverty, Vulnerability and Food Consumption Inequality among Smallholder Households in Ghana: A Gender – Based Perspective." *Social Indicators Research*, 0123456789. doi:10.1007/s11205-022-02913-w.

Anang, Benjamin Tetteh, Emmanuel Owusu Dokyi, Bright Owusu Asante, and Samuel A Donkoh. 2022. "Technical Efficiency of Resource - Poor Maize Farmers in Northern Ghana." *Open Agriculture* 7: 69–78.

Assefa, Abebe, Aemiro Bezabih, Getaway Girmay, Tesfaye Alemayehu, and Alemu Lkaw. 2020. “Evaluation of Sorghum (Sorghum Bicolor (L.) Moench) Variety Performance in the Lowlands Area of Wag Lasta, North Eastern Ethiopia.” *Cogent Food & Agriculture* 6 (1). doi:10.1080/23311932.2020.1778603.

Bello, Lateef Olalekan, Lloyd J.S. Baiyegunhi, Gideon Danso-Abbeam, and Abiodun A. Ogundeji. 2021. “Gender Decomposition in Smallholder Agricultural Performance in Rural Nigeria.” *Scientific African* 13: e00875. doi:10.1016/j.sciaf.2021.e00875.

Cervantes-godoy, Dalila. 2015. “Strategies for Addressing Smallholder Agriculture and Facilitating Structural Transformation.” *OECD Food, Agriculture and Fisheries Papers, No. 90, OECD Publishing*, no. 90.

Chigbu, Uchendu, Gaynor Paradza, and Walter Dachaga. 2019. “Differentiations in Women’s Land Tenure Experiences: Implications for Women’s Land Access and Tenure Security in Sub-Saharan Africa.” *Land* 8 (2): 1–22. doi:10.3390/land8020022.

Danso-Abbeam, Gideon, Lloyd J.S. Baiyegunhi, and Temitope O. Ojo. 2020. “Gender Differentials in Technical Efficiency of Ghanaian Cocoa Farms.” *Heliyon* 6 (5): 4–12. doi:10.1016/j.heliyon.2020.e04012.

Djurdjevic, Dragana, and Sergiy Radyakin. 2007. “Decomposition of the Gender Wage Gap Using Matching: An Application for Switzerland.” *Swiss Journal of Economics and Statistics* 143 (4): 365–396. doi:10.1007/BF03399243.

Djurfeldt, Agnes Andersson, Göran Djurfeldt, Ellen Hillbom, Aida C Isinika, Miriam Dalitso, Kalanda Joshua, Wisdom Chilwizhi, et al. 2019. “Is There Such a Thing as Sustainable Agricultural Intensification in Smallholder-Based Farming in Sub-Saharan Africa ? Understanding Yield Differences in Relation to Gender in Malawi, Tanzania and Zambia.” *Development Studies Research* 6 (1): 62–75. doi:10.1080/21665095.2019.1593048.

Donald, Aletheia, Julia Vaillant, Francisco Campos, and Maria Emilia Cucagna. 2018. “Caring about Carework: Lifting Constraints to the Productivity of Women Farmers in the Democratic Republic of the Congo.” Gender Innovation Lab. Washington, D.C.: World Bank.

Fortin, Nicole, Thomas Lemieux, and Sergio Firpo. 2010. “Decomposition Methods in Ecnomics.” *NBER Working Paper No.* 16045, 1–118. doi:10.1016/S0169-7218(11)00407-2.

Gebre, Girma Gezimu, Hiroshi Isoda, Dil Bahadur Rahut, Yuichiro Amekawa, and Hisako Nomura. 2021. “Gender Differences in Agricultural Productivity: Evidence from Maize Farm Households in Southern Ethiopia.” *GeoJournal* 86 (2): 843–864. doi:10.1007/s10708-019-10098-y.

Ingutia, Rose, and John Sumelius. 2022. “Do Farmer Groups Improve the Situation of Women in Agriculture in Rural Kenya?” *International Food and Agribusiness Management Review* 25 (1): 135–156. doi:10.22434/IFAMR2020.0142.

Joe-Nkamuke, Uzoamaka, Kehinde Oluseyi Olagunju, Esther Njuguna-Mungai, and Kai Mausch. 2019. “Is There Any Gender Gap in the Production of Legumes in Malawi? Evidence from the Oaxaca–Blinder Decomposition Model.” *Review of Agricultural, Food and Environmental Studies* 100 (1–4): 69–92. doi:10.1007/s41130-019-00090-y.

Khan, Md Riyazuddin, Mohammad Imdadul Haque, Noorsaba Khatoon Zeeshan, Isha Kaushik, and Karuna Shree. 2021. “Caste, Land Ownership and Agricultural Productivity in India: Evidence from a Large-Scale Survey of Farm Households.” *Development in Practice* 31 (4): 421–431. doi:10.1080/09614524.2020.1853679.

Kilic, Talip, Amparo Palacios-López, and Markus Goldstein. 2015. “Caught in a Productivity Trap: A Distributional Perspective on Gender Differences in Malawian Agriculture.” *World Development* 70 (5): 416–463.

Kloss, Mathias, and Martin Petrick. 2018. “The Productivity of Family and Hired Labour in European Union Arable Farming.” 174. Leibniz Institute of Agricultural Development in Transition Economies Halle (Saale), Germany.

Kumar, Ashok, Shivaji P Mehtre, Kotla Anuradha, Jayakumar Jaganathan, Hari Prasanna, Sunita Gorthy, and Sharad Rao. 2018. *Delivering Bioavailable Micronutrients Through Biofortifying Sorghum and Seed Chain Innovations*. Patancheru, India: ICRISAT.

Mango, N., Makate, C., Hanyani-mlambo, B., Siziba, S. and Lundy, M. (2015). A stochastic frontier analysis of technical efficiency in smallholder maize production in Zimbabwe : The post-fast-track land reform outlook. *Cogent Economics and Finance*, 6 (1): 1–14.

Miriti, Philip, David Jakinda Otieno, Evans Chimoita, Edward Bikketi, Esther Njuguna, and Chris O. Ojiewo. 2021. “Technical efficiency and technology gaps of sorghum plots in Uganda: A gendered stochastic metafrontier analysis.” *Heliyon* 7 (1): e05845.

Mugisha, Johnny, Christopher Sebatta, Kai Mausch, Elizabeth Ahikiriza, David Kalule Okello, and Esther M. Njuguna. 2019. “Bridging the Gap: Decomposing Sources of Gender Yield Gaps in Uganda Groundnut Production.” *Gender, Technology and Development* 23 (1): 19–35. doi:10.1080/09718524.2019.1621597.

Mukasa, Adamon N, and Adekele O Salami. 2016. “Sources of Gender Productivity Differentials in Africa : A Cross-Country Comparison.” *Africa Economic Brief* 7 (4): 1–16.

Mundia, Clara W., Silvia Secchi, Kofi Akamani, and Guangxing Wang. 2019. “A Regional Comparison of Factors Affecting Global Sorghum Production: The Case of North America, Asia and Africa’s Sahel.” *Sustainability* 11 (7): 2135–2145.

Muyanga, Milu, and T. S. Jayne. 2019. “Revisiting the Farm Size-Productivity Relationship Based on a Relatively Wide Range of Farm Sizes: Evidence from Kenya.” *American Journal of Agricultural Economics* 101 (4): 1140–1163.

Mwololo, Henry Muli, Jonathan Makau Nzuma, Cecilia Nyawira Ritho, Henry Muli, Jonathan Makau Nzuma, and Cecilia Nyawira Ritho. 2019. “Is the Type of Agricultural Extension Services a Determinant of Farm Diversity ? Evidence from Kenya.” *Development Studies Research* 6 (1): 40–46.

Nangobi, R., and B. Mugonola. 2018. "Determinants of Collective Marketing and Marketable Surplus for Smallholder Sorghum Producers in Oyam District, Uganda." *Journal of Development and Agricultural Economics* 10 (7): 213–224. doi:10.5897/jdae2018.0943.

Nchanji, Eileen B., Odhiambo A. Collins, Enid Katungi, Agness Nduguru, Catherine Kabungo, Esther M. Njuguna, and Chris O. Ojiewo. 2021. "What Does Gender Yield Gap Tell Us About Smallholder Farming in Developing Countries?" *Sustainability (Switzerland)* 13 (1): 1–20. doi:10.3390/su13010077.

Nsanja, Lamulo, Ben M Kaluwa, and Winford H Masanjala. 2021. "Gender Gap in Agricultural Productivity in Malawi." *International Journal of Science Academic Research*, 2 (5): 1488–1496.

Oaxaca, Ronald. 1973. "Male-Female Wage Differentials in Urban Labor Markets." *International Economic Review* 14 (4): 693–709.

Oaxaca, Ronald. 2007. "The Challenge of Measuring Labor Market." *Swedish Economic Policy Review* 14: 199–231.

Osanya, Jessica, Rahma I. Adam, David Jakinda Otieno, Rose Nyikal, and Moti Jaleta. 2020. "An Analysis of the Respective Contributions of Husband and Wife in Farming Households in Kenya to Decisions Regarding the Use of Income: A Multinomial Logit Approach." *Women's Studies International Forum* 83: 102419. doi:10.1016/j.wsif.2020.102419.

Palacios-Lopez, Amparo, Luc Christiaensen, and Talip Kilic. 2017. "How Much of the Labor in African Agriculture Is Provided by Women?" *Food Policy* 67: 52–63. doi:10.1016/j.foodpol.2016.09.017.

Palacios-Lopez, Amparo, and Romon Lopez. 2015. "The Gender Gap in Agricultural Productivity: The Role of Market Imperfections." *The Journal of Development Studies* 51 (9): 1175–1192.

Peterman, Amber, Agnes Quisumbing, Julia Behrman, and Ephraim Nkonya. 2011. "Understanding the Complexities Surrounding Gender Differences in Agricultural Productivity in Nigeria and Uganda." *Journal of Development Studies* 47 (10): 1482–1509. doi:10.1080/00220388.2010.536222.

Priegnitz, Uta, Willemien J.M. Lommen, Stephen Onakuse, and Paul C. Struik. 2019. "A Farm Typology for Adoption of Innovations in Potato Production in Southwestern Uganda." *Frontiers in Sustainable Food Systems* 3: 1–15. doi:10.3389/fsufs.2019.00068.

Rajkhowa, Pallavi, and Matin Qaim. 2021. "Personalized Digital Extension Services and Agricultural Performance: Evidence from Smallholder Farmers in India." *PLoS ONE* 16: 1–23. doi:10.1371/journal.pone.0259319.

Sell, Mila, Stefan Bäckman, Benjamin Tettehanang, and Jarkko K Niemi. 2018. "The Unequal Efficiency Gap: Key Factors Influencing Women Farmer's Efficiency in Uganda." *Cogent Food & Agriculture* 4 (1): 1–18. doi:10.1080/23311932.2018.1551750.

Sell, Mila, and Nicholas Minot. 2018. "What Factors Explain Women's Empowerment? Decision-Making among Small-Scale Farmers in Uganda." *Women's Studies International Forum* 71: 46–55. doi:10.1016/j.wsif.2018.09.005.

Sheng, Yu, Jiping Ding, and Jikun Huang. 2019. "The Relationship Between Farm Size and Productivity in Agriculture: Evidence from Maize Production in Northern China." *American Journal of Agricultural Economics* 101 (3): 790–806.

Singbo, A., E. Njuguna-Mungai, J. O. Yila, K. Sissoko, and R. Tabo. 2021. "Examining the Gender Productivity Gap among Farm Households in Mali." *Journal of African Economies* 30 (3): 251–284. doi:10.1093/jae/ejaa008.

Tenywa, Moses M, Rebecca Kalibwani, Sospeter O Nyamwaro, Josaphat Mogabo, M. Moses, Robin Buruchara, and Fatunbi Oluwole. 2018. "Innovation Opportunities in Sorghum Production in Uganda." *FARA Research Reports* 2 (18): 20.

UBOS. 2016. "The National Population and Housing Census 2014- Main Report." Kamapala, Uganda.

UBOS. 2017a. "National Population and Housing Census, Lira District." Area Specific Profile Series, Kampala, Uganda.

UBOS. 2017b. "National Population and Housing Census 2014, Serere District." Area Specific Profile Series, Kampala, Uganda.

UBOS. 2017c. "The National Population and Housing Census 2014, Kumi District." Area Specific Profile Series, Kampala, Uganda.

Udry, Christopher, John Hoddinott, Harold Alderman, and Lawrence Haddad. 1995. "Gender Differentials in Farm Productivity: Implications for Household Efficiency and Agricultural Policy." *Food Policy* 20 (5): 407–423. doi:10.1016/0306-9192(95)00035-D.

USDA. 2018. "Sorghum Production Quantities." https://www.ers.usda.gov/data-products.

Wang, Sun Ling, Paul Heisey, David Schimmelpfennig, and Eldon Ball. 2015. "Agricultural Productivity Growth in the United States: Measurement, Trends and Drivers." U.S. Department of Agriculture, Economic Research Service, July 2015, Washington.

World Bank. 2018. *Closing the Potential Performance Divide in Ugandan Agriculture*. Washington, DC: World Bank.

Wouterse, Fleur, and Ousmane Badiane. 2019. "The Role of Health, Experience, and Educational Attainment in Agricultural Production: Evidence from Smallholders in Burkina Faso." *Agricultural Economics (United Kingdom)* 50 (4): 421–434.