He Says, She Says, the GPS Says: Gender Gaps in Agricultural Survey Responses in Ghana

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Abstract

Recent work shows substantial disagreement between spouses in survey responses about household assets, income, and decision-making. However, to date, this work has not yet assessed whether this disagreement reflects biased responses, and whether standard survey protocols obtain biased estimates. Many agricultural surveys, for example, across the developing world typically interview only one respondent about the characteristics, inputs, and outputs of farm plots, even when multiple household members make decisions about plots. To address this challenge, we individually interview both husbands and wives about all farm plots in 1,243 households in Northern Ghana, and–critically–also collect a third independent observation generated using GPS plot walks and satellite imagery. We find significant disagreement between husbands and wives on even the most basic aspects of household farm plots, including the number of plots and the main decision-making roles on plots. Moreover, we find significant gender-related bias in reports when we match survey data to independent observations of plot size and distance from houses as measured by a GPS receiver, as well as whether a plot is fallowed as observed via satellite imagery. Men are differentially likely to overstate farm production (in terms of both plot size and whether the plot is farmed or fallowed), especially on plots for which they report having decision-making responsibilities. They are also differentially likely to understate the implicit labor costs for plots on which their wives have decision-making responsibilities.

Keywords: Gender gaps, intrahousehold, agriculture surveys

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1 Introduction

Over the past half-century, nationally representative agricultural surveys have become the dominant source for drawing population-scale estimates of agricultural practices and production. For example, since its launch in 1950, the FAO's World Agriculture Census has provided estimates of global agricultural holdings representing more than half a billion people (FAO, 2019). Similarly, the World Bank's Living Standards Measurement Survey (LSMS) has represented the agricultural experiences of 6.9 billion people through 115 nationally representative surveys since 1980 (Census, 2023; WB, 2023). The LSMS has recently progressed to allow up to 2 individuals in each household to be listed as plot owners (Doss, Kieran and Kilic, 2017). Similarly, the FAO's Census allows the holder to be listed as individual or joint (GSS, 2017). However, both surveys only allow one individual per plot to share information on inputs, plot characteristics, and crop yields. Often, the primary survey respondent (frequently, the male head of household) delineates who holds primary decision-making responsibility over each plot, and thus who should respond to subsequent questions about that plot.

Recent work has identified substantial spousal disagreement in an array of household survey responses. Husbands and wives have been shown to disagree on which assets are present in the household (Silverio-Murillo, 2018), income (Fisher, Reimer and Carr, 2010), labor productivity (Dervisevic and Goldstein, 2023), land ownership (Twyman, Useche and Deere, 2015; Moylan, Koolwal and Kilic, 2021), agricultural and non-agricultural decision-making (Ambler et al., 2021; Acosta et al., 2020; Seymour and Peterman, 2018; Ambler et al., 2022; Hillelsand et al., 2020), household authority (Anderson, Reynolds and Gugerty, 2017), farm output (Van Campenhout, Lecoutere and Spielman, 2023), and women's autonomy (Jejeebhoy, 2002).

This disagreement suggests that there is likely substantial measurement error in many responses to household or agricultural surveys. However, the extent of gender-specific bias in such survey responses has not yet been measured. Without an independent third observation, we cannot assess estimate bias in survey reporting, nor link this to the gender of the respondent.

We provide two key contributions. First, by independently interviewing both spouses in 1,243 households in Northern Ghana about all of the plots each household farms, we document substantial spousal disagreement in even the most basic features such as the number of plots farmed by the household. In nearly a third of households, spouses disagree on the number of plots or decision-making roles on these plots. Second, we use Geographic Information Systems (GIS) to collect independent observations of plots, which allow us to estimate gender-specific bias. We directly measure the difference between reported and directly observed characteristics such as plot size, distance from house to plot, and plot fallowing as seen in satellite imagery. Men are differentially likely to overstate a plot's size, particularly for plots on which they report having decision-making responsibilities. They are also differentially likely to under-report their distance from their home to the plots on which their wives have decision-making responsibilities. Finally, men are also more likely to report farming production on plots that are observed as fallow via satellite imagery.

These findings suggest that much more careful attention needs to be paid to survey protocols for choosing whom to interview about each plot. In many cases where male household members are the primary respondents, asking them to identify the plots and associated decision-making roles likely leads to overstating men's agricultural production and understating the costs women bear on plots that they farm. We estimate that, in our sample, using the males as the primary respondents likely leads to an increase in the bias of responses of %. Future research should thus explore the effectiveness of alternative protocols, including using women as the primary respondents, randomly assigning the gender of the primary respondent, or interviewing both respondents for a subsample of households and correcting for potential bias in the full sample using findings from this subsample.

The paper proceeds as follows: Section 2 provides context on household dynamics in our study setting of Northern Ghana; Section 3 describes the literature on disagreement and bias in household surveys; Section 4 lays out our data collection and discusses disagreement observed in the survey responses; Section 5 details the empirical specifications used to estimate bias, while Section 6 presents the associated results; Section 7 provides robustness checks and and Section 8 concludes.

2 Household Dynamics in Northern Ghana

As in many regions of the developing world, many people in Northern Ghana believe men to be the rightful heads of household (USAID, 2021). Men's perceived roles as breadwinners and women's perceived roles as caretakers and supporters lead women to resort to vulnerable employment opportunities (WAGE, 2022; Amu, 2006). Especially in rural areas, women are limited to unpaid agricultural labor on their husband's land, despite the critical role they play in production (USAID, 2021).

Traditional views of land ownership play a key role in women's exclusion from the agricultural economy. Customary lands make up an estimated 80% of the country, meaning that in patrilineal Northern Ghana, men receive exclusive rights to land (FAO, 2023). Women's access to land is thus directly tied to marriage and their husbands' lineage. In the event of divorce or her husband's death, a woman stands to lose all land access and thus her best chance at economic stability in a predominantly agricultural economy (FAO, 2023).

In the majority-Muslim Northern region of Ghana, customary marriage laws exacerbate gender inequality. Men and women have equal rights in entering and registering a marriage according to statutory law. However, in Islamic marriages, a wife cannot be present at marriage registration and divorce proceedings, further entrenching patriarchal norms (WAGE, 2022). Additionally, polygamous unions are estimated to make up 23% of all marriages in the country and are concentrated in the Northern Region (FAO, 2023).

Ghana has a gendered division of agricultural labor which creates additional disparities in income and opportunity. Men typically produce cash crops such as cocoa (FAO, 2023) that generate substantial income. Women are primarily engaged in cereal and vegetable production, crops which are consumed by the household (CCAFS, 2021). Additionally, due to care responsibilities, women have less time to sell crops at markets and participate in agricultural extension activities which can increase their productivity. Furthermore, when women lose access to a husband's land do to either divorce or death, they are often limited to picking and processing shea (a tropical tree) nuts into butter, harvesting and processing dawadawa (locust beans) common to northern Ghana, or brewing pito (a local alcoholic beverage made from malt) for sale (Akuguru, 2020).

Northern Ghana's limited economic and social rights for women, power imbalances between genders, and gendered division of agricultural labor understandably coincides with disagreement between spouses on even the most basic questions about agricultural holdings. While it remains unclear whether information hiding, naturally-occuring asymmetric information within couples, or another mechanism causes these disagreements, it is important to consider the highly patriarchal context when analyzing agricultural reporting bias in Northern Ghana.

3 Disagreement and Bias in Household Surveys

Survey answers to the same question often differ within households, especially depending on the gender of the interviewee. For example, Moylan, Koolwal and Kilic (2021) assessed land ownership in two concurrent national surveys in Malawi, one of which interviewed one knowledgeable household member and another which interviewed all adult household members. Interviewing one household member led to higher rates of men's exclusively reported land ownership, as well as women's lower reported joint land ownership. For younger to middle-aged women, private individual interviews led to a higher share of women claiming reported/economic joint and individual ownership, as well as rights.

A growing body of evidence shows similar disagreements between spouses within the same survey. Women are more likely than men to say that women own household assets (Ambler et al., 2021). Men report lower levels of women's participation compared to their wives in management of agricultural activities (Hillelsand et al., 2020) and agricultural and non-agricultural decision-making (Twyman, Useche and Deere, 2015; Ambler et al., 2022; Acosta et al., 2020). Even seemingly objective questions about the existence of assets and farm income show high levels of disagreement. Castilla (2013) shows that women co-heads in southern Ghana report 14% less farm income than male co-heads, on average. Silverio-Murillo (2018) finds that 24% of couples disagree on the existence of a washing machine in their home and 10% disagree on whether the household owns land apart from the home.

Our first contribution is the exposure of fundamental agricultural disagreement, most notably on the existence of plots. Couples disagree on the existence of 27% of plots reported which can help explain previous studies' findings on disagreement in agricultural decision-making and farm income.

One study in particular attempts to push beyond disagreement to estimate bias, yet is constrained by a lack of independent measures of disagreed-upon variables. Dervisevic and Goldstein (2023) find that men report fewer hours spent working on their spouses' plots than female managers report of their husbands' work, likely due to social desirability. The authors consequently claim that using self-reports by male workers would lead to underestimating the hours they spend providing labor on their spouse's plots. However, hours worked is still only a disagreement between two people, not a measure of the difference between reported and true values. The limits of disagreement to explain bias are further demonstrated by the authors' admission that they could also be underestimating male workers' labor hours when using female managers' reports. Without an objective independent observation to compare to reported observations, bias is impossible to measure, and therefore systematic under or over-reporting is as well.

We make the first contribution to measuring bias on basic agricultural features. We introduce independent measures of plot characteristics acquired through GIS and remote sensing.

We are not yet able to measure the spousal disagreement literature's most heavily studied topics such as agricultural decision-making and asset ownership using GIS. However, we use these basic plot characteristics as a first step towards understanding how leaving out certain perspectives might influence non-classical measurement error in agricultural reporting. While previous work raises important questions on survey accuracy due to disagreement, we offer survey strategies to minimize bias.

4 Data

4.1 Survey and GIS Data

Within each village, we conducted 26 individual surveys in 13 households, interviewing a man and woman in each household. As such, we conducted 828 surveys in 414 households in the Northern region and the Upper East Region, 830 surveys in 415 households in the Upper West region, for a total of 2,486 surveys in 1,243 households. Enumerators selected individual respondents through a random walk pattern.

Each household was asked a series of screening questions to identify if the household meets the inclusion criteria. The first inclusion criteria was that both a man and woman (married or partners) must be available for a survey. The second inclusion criteria was that the man and woman must each make decisions over at least one plot that had been planted at least once in the last 3 years and was within a 30 minute walk of the household. While they do not need to own this plot, they must make some decisions about it. For households that have multiple wives, one wife was randomly selected among all wives/partners who make decisions over a plot.

The survey collected information on demographics, livelihoods, water access and sanitation, community involvement, trust in government, retrospective information on agriculture and irrigation, time use, and decision-making and empowerment. Selected couples were interviewed at the same time in separate locations where they could not overhear one another.

This was done to prevent any input from the spouse on survey answers to ensure the answers we received were solely from the respondent.

As part of this survey, enumerators also collected GPS boundaries of household agricultural plots within approximately 30 minutes of the household. We asked enumerators to take quick notes on identifiable information for each plot they discussed so when they asked the respondent to show them the first plot they talked about they could give them the identifying information about the plot such as "the plot with the maize by the well". Due to time and costs, we limited the collection of the GPS information to plots within 30 minutes of the house.

After collecting the survey data, it became evident that there was a large degree of discordance between husbands and wives on the number, location, and boundaries of household plots. For instance, although most couples (73.7%) agreed on the number of plots owned by the household (Table 1: shaded cells), there was also significant disagreement (Table 1: non-shaded cells). In fact, over a quarter of couples (26.3%) disagreed on the number of household plots.

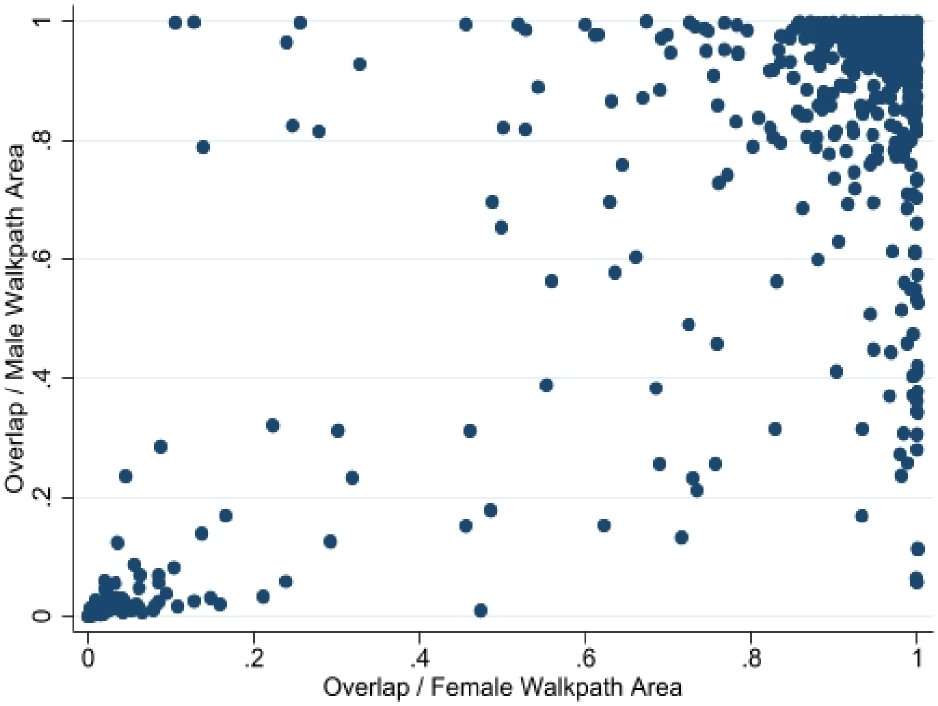
Table 1: Agreement in Number of Plots between Husbands and Wives

		Number of Plots Reported by Woman							
		0	1	2	3	4	5	6	Total
Number of Plots Reported by Man	0	0	3	2	0	0	0	0	5
	1	1	400	66	11	2	0	1	481
	2	4	98	393	34	3	0	0	532
	3	2	27	46	109	4	0	0	188
	4	1	5	6	6	11	0	0	29
	5	0	0	1	0	2	2	0	5
	6	0	0	0	2	0	0	0	2
	Total	8	533	514	162	22	2	1	1242

Beyond disagreement on the number of household plots, there was also a large amount of disagreement on the location and boundaries of reported plots. Since husbands and wives were interviewed separately, the order in which plots were reported could not be used to match reports between the individual survey responses. We therefore relied on joining overlapping polygons of plot walk paths from husbands and wives to match up survey responses about plots.

When we joined husbands' and wives' overlapping plots on the basis of plot walk paths, it became evident that husbands and wives often had divergent plot walk paths. Figure 1 demonstrates the concordance in location and boundaries of these matched overlapping plot walk paths, where the x-axis represents the area of overlap divided by the total area of the woman's plot walk path, and the y-axis represents the area of overlap divided by the total area of the man's plot walk path (i.e. a point at 1 on both axes would indicate exactly overlapping plot walk paths). The data demonstrates that husbands and wives often report differing plot boundaries for overlapping plots.

Figure 1: : Concordance in Location and Boundaries of Husbands' and Wives' Overlapping Plot Walk Paths



To ensure our analysis compares husbands' and wives' reports on the same plot of land, we restrict our analyses that utilize both a husband's and wife's responses on a plot to matched overlapping plots with at least 90% overlap in both axes (i.e. the upper right corner of Figure 1).

In addition, we attempt to reduce enumerator error in the matching of GPS plot walk paths to plot reports in the survey by restricting the sample for all analyses in the following ways: by dropping plots for which the ranked straight-line distance from house to plot and ranked area of the plot walk path was not the same as the ranked reported distance and reported area of the plot in the survey, respectively, and by also dropping plots for which actual or reported plot area was greater than 20 acres and for which straight line distance from house to plot was greater than 4 km or reported distance was greater than 100 minutes.

Once we narrowed our sample in this way to ensure we only considered plots for which we had a high degree of confidence that husbands' and wives' reports corresponded, we were able to consider concordance on reports about ownership on these plots. Table 2, Panel A demonstrates concordance on female ownership over matched plots, and Panel B demonstrates concordance on male ownership over these same plots. There is a high degree of discordance over ownership of plots, with 46.2% and 48.7% of couples disagreeing on female and male ownership roles, respectively.

Similarly, we consider concordance on reports about decision-making on these plots. Table 3, Panel A demonstrates concordance on female decision-making over matched plots, and Panel B demonstrates concordance on male decision-making over these same plots. There is less disagreement about decision-making roles than over ownership stakes. Even so, there remains a significant degree of discordance over decision-making roles of household plots, with 31.7% and 29.8% of couples disagreeing on female and male decision-making roles, respectively.

Table 2: Concordance on Ownership

Panel A: Concordance on Female Ownership

		Female Report			
		Female Sole Ownership	**Female Partial Ownership**	**Female No Ownership**	**Total**
Male Report	**Female Sole Ownership**	0	3	2	5
	Female Partial Ownership	21	163	42	226
	Female No Ownership	18	122	81	221
	Total	39	288	125	452

Panel B: Concordance on Male Ownership

		Female Report			
		Male Sole Ownership	**Male Partial Ownership**	**Male No Ownership**	**Total**
Male Report	**Male Sole Ownership**	67	117	19	203
	Male Partial Ownership	28	161	27	216
	Male No Ownership	10	19	4	33
	Total	105	297	50	452

These findings demonstrate a high degree of disagreement within couples on basic plot characteristics and highlight the danger in interviewing only one household member about agricultural plots. In cases where it is infeasible to interview multiple household members, agricultural surveys often default to interviewing the member of the household who is the primary owner or the primary decision-maker over the plot in question. These results further demonstrate the difficulties of using one household member's response to determine an interviewee under these conditions, as reports on ownership and decision-making may differ depending on who is surveyed.

Table 3: Concordance on Decision-making

Panel A: Concordance on Female Decision-making

		Female Report			
		Female Sole Decision-making	**Female Partial Decision-making**	**Female No Decision-Making**	**Total**
Male Report	**Female Sole Decision-making**	0	24	12	36
	Female Partial Decision-making	20	294	55	369
	Female No Decision-making	3	31	18	52
	Total	23	349	85	457

Panel B: Concordance on Male Decision-making

		Female Report			
		Male Sole Decision-making	**Male Partial Decision-making**	**Male No Decision-making**	**Total**
Male Report	**Male Sole Decision-making**	22	29	5	56
	Male Partial Decision-making	55	299	12	366
	Male No Decision-making	12	23	0	35
	Total	89	351	17	457

4.2 Remote Sensing

The geospatial analysis and remote sensing of agricultural plot characteristics took place during the analysis phase based on the GPS points of household agricultural plots collected in the individual survey. We first did extensive cleaning of the plot boundary data, and then used the resulting boundaries to construct area measures and distances between the plot and the household residence GPS taken during the survey. We then imported the plot boundaries into Google Earth Engine, and then used very high resolution (VHR) satellite imagery derived from Google Earth Pro to identify fallow plots (relative to planted plots). To do so, our team visually inspected imagery of all sample plots that was available over the primary growing season (June 16 - August 31) corresponding to our survey responses. We used the color and patterns on each plot to tag "farmed" and "unfarmed" plots. We were able to identify a reasonable share of plots that appeared not to be planted, substantially more than were reported to be fallow in our survey. We aggregated these data to create a plot-specific *fallow* variable that reflects whether the plot is observed as fallowed (or unfarmed) for all images over the season.

5 Empirical Strategy

We assume measurement error of survey-measured plot characteristics to take the following structure:

$$y_{ipv} = u_{pv} + \epsilon_{ipv}$$

where y_{ipv} is the survey-measured characteristic of plot p reported by individual i in village v, u_{pv} is the true value of the characteristic of plot p in village v, and ϵ_{ipv} is the measurement error in the survey measure of this characteristic for plot p reported by individual i in village v. That is, our data will take the format of plot-by-respondent. We do not know, a priori, the mean or distribution of ϵ_{ipv}.

We assumed measurement error of remotely sensed plot characteristics would take the following structure:

$$r_{pv} = u_{pv} + \eta_{pv}$$

where r_{pv} is the remotely sensed characteristic of plot p in village v, u_{pv} is the true value of the characteristic of plot p in village v, and η_{pv} is the measurement error in the remotely sensed measure of this characteristic for plot p in village v. η_{pv} is random measurement error.

As such, we estimate the difference between the survey-measured and remotely sensed plot characteristics, m_{ipv}, using the following:

$$m_{ipv} = y_{ipv} - r_{pv} = \epsilon_{ipv} - \eta_{ipv}$$

Since η_{pv} is random measurement error, the mean and distribution of m_{ipv} reveals the structure of measurement error inherent in survey reports of agricultural characteristics.

To consider the magnitude in measurement error on self-reported plot size by gender and ownership status, we utilize the following specification:

$$SizeDifference_{ipv} = \beta Male_i + \gamma Owner_{ipv} + \alpha Male_i * Owner_{ipv} + D_v + \mu_{ipv}$$

where $SizeDifference_{ipv}$ is the difference between the report of individual i on plot size of plot p in village v and measured plot size of plot p, $Male_i$ is a binary variable that is 1 if individual i is male and 0 otherwise, $Owner_{ipv}$ is a binary variable that is 1 if individual i reports that they are a sole or partial owner of plot p, and D_v are village fixed effects.

Similarly, we consider:

$$SizeDifference_{ipv} = \beta Male_i + \gamma Decider_{ipv} + \alpha Male_i * Decider_{ipv} + D_v + \mu_{ipv}$$

where $Decider_{ipv}$ is a binary variable that is 1 if individual i reports that they are a sole or partial decision-maker in the input purchase, time of harvest, and/or crop choices for plot p.

To consider the differences in the magnitude of measurement error in self-reported distance of plots from the household by gender and ownership status, we utilize the following specification:

$$ReportedDistance_{ipv} = \pi MeasuredDistance_{ipv} + \beta Male_i + \gamma Owner_{ipv}$$

$$+\alpha Male_i * Owner_{ipv} + D_v + \mu_{ipv}$$

where $ReportedDistance_{ipv}$ is the report of individual i on the distance in minutes (to walk one way) between plot p in village v and individual i's dwelling. $MeasuredDistance_{ipv}$ is the measured straight line distance between individual i's plot walk path of plot p and individual i's dwelling, $Male_i$ is a binary variable that is 1 if individual i is male and 0 otherwise. $Owner_{ipv}$ is a binary variable that is 1 if individual i reports that they are a sole or partial owner of plot p, and D_v are village fixed effects.

Similarly, we consider:

$$ReportedDistance_{ipv} = \pi MeasuredDistance_{ipv} + \beta Male_i + \gamma Decider_{ipv}$$

$$+\alpha Male_i * Decider_{ipv} + D_v + \mu_{ipv}$$

where $Decider_{ipv}$ is a binary variable that is 1 if individual i reports that they are a sole or partial decision-maker in the input purchase, time of harvest, and/or crop choices for plot p.

To consider the differences in the magnitude of measurement error in standardized amounts of reported crops harvested by gender and remotely sensed fallow status, we use the following specification:

$$StdHarvest_{ipv} = \beta RSFallow_{ipv} + \gamma Female_i + \alpha Female_i * RSFallow_{ipv} + D_v$$

$$+Maize_v + Millet_v + Groundnut_v + Yam_v + \mu_{ipv}$$

where $StdHarvest_{ipv}$ is the standardized amount of maize, millet, groundnuts, and yam harvested on plot p in village v reported by individual i, $RSFallow_i$ is a binary variable that is 1 if plot p appears to be fallow based on remote sensing and 0 if there appears to be crops planted on plot p, $Female_i$ is a binary variable that is 1 if individual i is female and 0 otherwise, D_v are village fixed effects, and $Maize_v$, $Millet_v$, $Groundnut_v$, and Yam_v are fixed effects for the respective crops.

To consider the differences in the magnitude of measurement error in reports of any staple crop having been planted by gender and remotely sensed fallow status, we use the following specification:

$$StaplePlanted_{ipv} = \beta RSFallow_{ipv} + \gamma Female_i + \alpha Female_i * RSFallow_{ipv} + D_v + \mu_{ipv}$$

where $StaplePlanted_{ipv}$ is a binary variable that is 1 if any staple crop (maize, millet, groundnuts, or yam) were planted on plot p in village v according to individual i, $RSFallow_i$ is a binary variable that is 1 if plot p appears to be fallow based on remote sensing and 0 if there appears to be crops planted on plot p, $Female_i$ is a binary variable that is 1 if individual i is female and 0 otherwise and D_v are village fixed effects.

Similarly, to consider the differences in the magnitude of measurement error in reports of inter-cropping by gender and remotely sensed fallow status, we use the following specification:

$$InterCrop_{ipv} = \beta RSFallow_{ipv} + \gamma Female_i + \alpha Female_i * RSFallow_{ipv} + D_v + \mu_{ipv}$$

where $InterCrop_{ipv}$ a binary variable that is 1 if individual i reports that inter-cropping occurred on plot p.

Similarly, to consider the differences in the magnitude of measurement error in reports of the amount of each crop harvested by gender and remotely sensed fallow status, we use the following specification:

$$CropHarvest_{ipv} = \beta RSFallow_{ipv} + \gamma Female_i + \alpha Female_i * RSFallow_{ipv} + D_v + \mu_{ipv}$$

where $CropHarvest_{ipv}$ is the kilogram amount of each crop harvested on plot p reported by individual i.

6 Results

Our results show important differences in reporting of plot characteristics between men and women, even after we adjust for direct measures of those characteristics. We begin by examining plot sizes, with our primary variable constructed as the difference between the survey reported size and the GPS-based measurement. Table 4 shows our base specifications for our sample of 1,546 plots. In all specifications, we adjust for village FE to account for potential differences in reporting that may be correlated with other cross-village factors.

In Column 1 of Table 4, we find large and significant differences in the plot size reporting error across male and female respondents. The sample mean of reporting errors among women is 0.79 m^2, and the coefficient on male respondents indicates this error is nearly doubled among men, with the difference statistically significant at the 95% level. In Column 2, we adjust for whether the respondent reports playing a role in the decision-making over the plot, while Column 3 adds an interaction between male respondent and decision-making status. Notably, in Column 3, we find that the male difference in reporting errors over plot size arises largely on plots on which men exert decision-making power. The reference category is no decision-making involvement (i.e., only the spouse or another household member make decisions for that plot), and the large coefficient on the interaction of male respondent and decision-maker status in Column 3 indicates that the male reporting error is concentrated on those plots where men also report being involved in the decision-making.

Finally, in Column 4, we repeat these interactions but with reported ownership status over the plot (i.e., whether the respondent reports at least partial ownership over the plot). Ownership and decision-making status over plots are quite distinct in our sample. Among those plots where respondents report no decision-making role, less than 33% of respondents also report no ownership stake (with the majority of cases being reported as plots with joint ownership where the respondent nonetheless plays no decision-making role). Conversely, in the majority of cases where respondents report no ownership status, they nonetheless report playing a role in decision-making.

In Column 4 of Table 4, we find much noisier estimates based on ownership status, but no strong evidence of differential reporting errors on the basis of ownership status, and no significant differences across genders. Taken together, we interpret these results as highly indicative that men report differentially larger sizes of plots than our team measured when they report playing a role in decision-making.

Next, we turn to measurement error in the reported distance of each plot from the respondent's residence. Because respondents report this quantity as the time required to travel the distance, we adjust (control) for the actual distance measured on the right hand side of our specifications (as described in the Methods section above). In Table 5, we find that male respondents differentially report shorter times to reach each plot than do women (for the same plot). The sample mean time to reach a plot reported by a woman is approximately 12 minutes, and men report times that are roughly 1-3 minutes shorter on average. Because we adjust for the actual distance to the plot, these differences can be interpreted as gender-specific reporting errors.

In Column 2, we adjust for and then interact with the respondent's decision-making status. We find that male respondents differentially report shorter times to reach plots over which they do not report making decisions, with this difference largely eliminated for plots

Table 4: Impact of Plot Decision-making, Plot Ownership, and Gender on Differences in Reported and Actual Plot Size

	(1)	(2)	(3)	(4)
DV= Reported Size - Actual Size (sq. meters)				
Male	0.272***	0.270**	-0.167	0.551
	(0.103)	(0.105)	(0.257)	(0.433)
Decider		0.0161	-0.157	
		(0.167)	(0.205)	
Male*Decider			0.497*	
			(0.291)	
Owner				0.331*
				(0.179)
Male*Owner				-0.395
				(0.460)
Observations	1,546	1,546	1,546	1,507
Female sample mean	0.274	0.274	0.274	0.274

Village fixed effects and standard errors in parentheses clustered by household.
*** p<0.01, ** p<0.05, * p<0.1

Table 5: Impact of Plot Decision-making, Plot Ownership, and Gender on Reported Plot Distance from House

	(1)	(2)	(3)
DV = Reported Distance from Residence to Plot (mins)			
Actual Distance from Residence to Plot (m)	0.0111***	0.0111***	0.0112***
	(0.00114)	(0.00114)	(0.00108)
Male	-1.065**	-2.547*	-1.905
	(0.535)	(1.306)	(2.035)
Decider		-0.452	
		(1.053)	
Male*Decider		1.672	
		(1.534)	
Owner			-0.270
			(0.859)
Male*Owner			0.914
			(2.185)
Observations	1,546	1,546	1,507
Female sample mean	11.64	11.64	11.64

Village fixed effects and standard errors in parentheses clustered by household.
*** p<0.01, ** p<0.05, * p<0.1

over which they do report some decision-making. In Column 3, we use a similar specification but using ownership status. Again, we find that men differentially report shortest times for plots they do not own, with this difference much smaller for plots over which they report some ownership stake.

Next, we consider measurement error in the reported harvest, planting, and inter-cropping decisions of plots. Constructing independent measures of these variables using remote sensing is complex. In this context, it is further complicated by widespread cloud cover in the main growing season and the widespread lack of planting in the dry season. For this reason, we focus our analysis on plots we observe to be fallow using remote sensing, as we expect there to be lower harvests and rates of planting or inter-cropping on these apparently fallowed plots.

In Table 6 Columns 1 and 2, we observe that men report differentially higher amounts harvests, but not differentially so in plots we observe to be fallow. However, in Column 4, we do find that men are more likely to report any staple crop being planted in those fields we observe to be fallow. Female respondents are 17% less likely to report a staple crop being planted on apparently fallow plots than non-fallow fields, but men are no more likely to do so at all. Similarly, in Column 6, we find that women are 30% less likely to report inter-cropping occurred in apparently fallowed fields relative to non-fallow fields. Men, again, are not likely to do so at higher rates on fallow than non-fallow fields. This suggests that there may be greater measurement error in men's reports on planting rates, and inter-cropping, and that these rates are likely to be biased upward in both cases.

We look more closely at measurement error in reported harvests for three staple crops - maize, millet, and groundnuts. Again, we compare responses on fields observed to be fallow and those observed not to be fallowed using remote sensing. Table 7 reports the results of this analysis. For both millet (Column 4), and groundnuts (Column 6), women report lower harvest amounts on apparently fallow plots relative to non-fallow plots. For both crops, men report *higher* harvests specifically on plots we observe as fallow relative to those we observe

Table 6: Remote Sensing and Survey Reports on Standardized Harvest Measures, Any Staple Crop Planted, and Inter-cropping

	(1) Std. Amount Harvested	(2) Std. Amount Harvested	(3) Any Staple Planted	(4) Any Staple Planted	(5) Inter-Cropping	(6) Inter-Cropping
Remotely-Sensed Fallow	0.453**	0.523***	-0.0970***	-0.173***	-0.142***	-0.303***
	(0.197)	(0.179)	(0.0237)	(0.0388)	(0.0323)	(0.0382)
Male	0.242***	0.265**	0.000506	-0.0255**	-0.0306	-0.0862***
	(0.0904)	(0.103)	(0.0117)	(0.0119)	(0.0199)	(0.0225)
Male x Remotely-Sensed Fallow		-0.136		0.157***		0.334***
		(0.317)		(0.0461)		(0.0617)
Observations	1,352	1,352	1,352	1,352	1,352	1,352
Village FEs	Y	Y	Y	Y	Y	Y
Crop-Specific FEs	Y	Y	N	N	N	N
Female sample mean	0.912	0.912	0.926	0.926	0.414	0.414

Standard errors in parentheses clustered by household.
*** p<0.01, ** p<0.05, * p<0.1

as not fallow. In other words, men's responses for these crops appears to directly contradict both women's responses and those observed from remote sensing. The magnitudes of these contradictions are quite large, equal to or even exceeding the mean harvest amounts reported by women.

Table 7: Remote Sensing and Survey Reports on Harvested Amounts of Staple Crops

	(1) Maize Harvested	(2) Maize Harvested	(3) Millet Harvested	(4) Millet Harvested	(5) Groundnuts Harvested	(6) Groundnuts Harvested
Remotely-Sensed Fallow	40.61	61.80	2.028	-36.17*	30.32	-67.56*
	(52.85)	(57.68)	(22.39)	(19.88)	(46.25)	(38.77)
Male	70.89*	77.71*	30.30*	17.13	38.84*	5.068
	(39.02)	(45.25)	(16.38)	(19.28)	(22.63)	(22.71)
Male x Remotely-Sensed Fallow		-41.34		79.23*		203.0**
		(94.19)		(45.00)		(82.99)
Observations	1,352	1,352	1,352	1,352	1,352	1,352
Village FEs	Y	Y	Y	Y	Y	Y
Crop-Specific FEs	N	N	N	N	N	N
Female sample mean	331.4	331.4	124.9	124.9	123.7	123.7

Village fixed effects, standard errors in parentheses clustered by household.
*** p<0.01, ** p<0.05, * p<0.1

7 Conclusion

Prior work establishes that husbands and wives disagree in their responses to a wide array of household survey questions, including both subjective as well as more objective questions. Concurring with this work, we find substantial disagreement in even basic features of household farming, such as the number of plots owned by a household. Moreover, we provide the first evidence that the differences in survey reporting exhibit gender-related bias. In order to address bias, a third independent observation of survey measures must be collected against which to compare survey reports. In this paper, we use GIS and remote sensing to provide this independent measure allowing us to directly measure the difference between reported and actual characteristics such as plot size, distance from house to plot, and plot fallowing as seen in satellite imagery.

We find that men differentially over-report farm production attributes, including plot sizes and millet and groundnut harvests. This is particularly true on plots where men report having more decision-making authority. At the same time, men also differentially understate the distance from the household (and thus the implicit labor costs) for those plots farmed exclusively by their wives. Taken together, it appears that men may differentially overstate total profits from plots that they exert at least some control over, and understate total profits from plots their wives control.

We consider whether alternative protocols to select respondents may induce less bias in overall estimates of these farm outcomes. Alternative protocols include (a) men report on all plots, (b) women report on all plots, (c) men report on all plots on which they state they are partial or sole deciders and women report otherwise, or (d) men report only on plots for which they state they are sole deciders and women report otherwise. Relative to the baseline protocol (a), protocol (b) results in 15% lower mean reported plot sizes and 10% greater mean plot distances from home. Protocol (d) achieves relatively similar results, with 13% lower plot sizes and 8% greater distances. Protocol (c) achieves less than 1% improvement on either measure, largely because men respond that they have at least partial decision-making power over such large shares of plots. While these measures do fully capture the extent of bias under each alternative, they are meant to capture the relative improvement afforded by each. The results suggest that interviewing women whenever possible–and at least for any plot over which they have at least some decision-making power–is vital to reducing the overall extent of bias in surveys.

Our findings also point to important directions for future research. First, while we identify the existence of gender-related bias in survey responses, future work may explore its sources and mechanisms. For example, what share of the bias in men's reports due to strategic (mis)reporting in the surveys, and what share is due to actual differences in their information sets? Second, while we study these questions in Ghana, where household members often have different decision-making and other roles over distinct plots, these intra-household dynamics are of course quite varied in other parts of sub-Saharan Africa and elsewhere. Extending this research to other settings is thus crucial for understanding the continent-wide and global-level extent of such gender-related survey biases.

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