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Does the landowner's gender affect farm productivity and self-cultivation?

An empirical analysis for India

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Abstract

The effect of tenure security conferred by land ownership on farm productivity has been much examined at the household level but rather little from a gender perspective. Equally, studies on gender differences in agricultural productivity are relatively few, and those focusing on the landowner's gender are even fewer. Moreover, the bulk of existing work on gender and farm productivity, and all the studies that additionally examine whether the landowner's gender makes a difference, relate to Sub-Saharan Africa. The few studies on Asia, including one on India, focus on the gender of farm managers rather than that of landowners. This paper fills this important research gap. It uses a unique household-level dataset for nine Indian states to examine differences in farm productivity between female and male landowners, controlling for inputs, and demographic and locational factors. It also demarcates the effect of caste, thus providing insights on the intersectionality of gender and caste, as well as region. In addition, it examines gender differences in the likelihood of landowners self-cultivating as opposed to leasing out their land, and the factors underlying observed differences. This is the first study for India and Asia which covers these varied dimensions.

We find no statistically significant difference in farm productivity per hectare between female and male landowner cultivator households, with or without controlling for input use, owner and household characteristics, and region. Caste matters, however: Scheduled Caste (SC) owner-cultivators of both genders have significantly lower productivity than upper-caste ones. Since 55% of female owner-cultivators in our sample are SC relative to 39% of the male owner-cultivators, gender linked with caste could constitute a notable disadvantage. Moreover, women owners are found significantly less likely to self-cultivate their land than male owners. This is linked especially to family labour constraints and regional opportunities.

Keywords

Gender differences, farm productivity, self-cultivation, caste, India

JEL Codes

J16, Q1, Q12, N55

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1. Introduction

With the feminisation of agriculture worldwide, the income and food security of rural households, as well as a country's agricultural growth, are likely to depend increasingly on the productivity of women farmers. However, substantial gender gaps in access to land, inputs, extension information, technology and markets can seriously limit this productivity.

In 2011, the Food and Agriculture Organization's (FAO) State of Food and Agriculture Report focused particular attention on the relative productivity of male and female farmers, arguing that reducing the constraints faced by women could help raise yields on their farms by 20% to 30% (FAO, 2011). Studies on the gender gap in farm productivity are relatively few, however, and those for Asia are exceedingly sparse. The FAO report drew on 24 empirical studies (summarised in Agarwal, 2014), 22 relating to Sub-Saharan Africa and two to Asia. Since then, further work has emerged. But of the 30 studies we could locate to date, the vast majority were still on Sub-Saharan Africa, covering 14 countries, and only five were for Asia, covering five countries (of which only one was for India). Moreover, none of the Asia-related research examined the effect of women *owning* land.[1] Nine African studies *did* have land ownership data by gender, and they examined whether women cultivating their owned plots made a particular difference,[2] but in most of these studies the focus was on overall productivity, with land ownership being used as an incidental variable.

Tenure security that comes with owning the land a farmer cultivates has long been argued to have several positive effects. To begin with, it has been found to raise the farmer's incentive to make long-term investments in the land, such as improvements in soil quality, terracing, bunding, creating irrigation channels, purchasing irrigation equipment, fallowing, and so on (Schweigert, 2006; Deininger & Chamorrro, 2004; Deininger & Jin, 2006; Ma, 2013; Maravi & Navarro, 2019; Fort, 2007; Goldstein & Udry, 2008). Land ownership can also improve access to credit (in terms of sources, amounts and terms), since land can serve as collateral (Binswanger & Feder, 2009), although the possibilities vary by context (Deininger & Feder 2009), and owner-cultivators typically have better access than tenants to extension information via agricultural extension agents (Sugden, 2010). Moreover, government subsidies tend to be directed

[1] The studies for Asia are Jamison and Lau (1982) for the Republic of Korea, Mahajan (2019) for India, Mishra et al (2017) and Thapa (2008) for Nepal, and Zhang et al (2004) for China.
[2] The nine are: Adele et al (2008), Aguilar et al (2015), Backiny-Yetna & McGee (2015), Gebre et al (2021), Kilic et al (2015), Palacios-López & López (2015), Peterman et al (2011), Quisumbing et al (2001) and Saito et al (1994). See also Doss (1999) and Quisumbing (1996) for overviews on some aspects.

to owner-cultivators, especially in contexts where leases are oral and lessors cannot provide documents to prove that they are the actual cultivators (Agarwal, 2018).[3]

Most of the literature on the benefits of tenure security via land ownership fails to provide a gender analysis, however. There appear to be only a few studies which specifically examine whether owning land has similar enabling effects for female farmers as for male farmers. Much of the evidence relates to the negative effects of women's lack of land ownership. For example, several studies, some from the 1990s, demonstrate that women's lack of land titles reduces their access to credit, agricultural extension (Saito et al, 1994; Meinzen-Dick et al, 2011) and government subsidies (Agarwal, 2018; Sugden et al, 2021). Women also need to own land to take advantage of extension information for adopting new technologies (Meinzen-Dick et al, 2010). In addition, there is tangential evidence from a 1990s study for Kenya which found that control over the fruits of their labour (which we would expect to come with tenure security) can enhance women's incentive to work harder on the land (Ongaro, cited in Elson, 1995). In that study, the introduction of weeding technology in maize production raised crop yields in female-headed households by 56% where women controlled the output, but only by 15% in male-headed households where too women weeded but men got the proceeds. The study does not specifically mention women owning the land they farmed in female-headed households, but they did have control over its use and probably owned it too.

Nevertheless, there are reasons to expect that gender constraints would limit the extent to which tenure security alone can lead to greater investments by women, or enhance their credit and extension access. Investments need supplementary finances and other inputs, such as command over labour, especially male labour, to make substantial improvements in the land. Using land as collateral for credit could again involve negotiating with male family members, and access to extension and technical training tends to be limited in conservative cultures in the absence of female extension agents, due to social norms that discourage male–female public interactions or other biases (FAO, 2011; Berger et al, 1984). Further, a recent review of *perceptions* of tenure security across 33 countries found some notable gender differences: men were more likely to feel insecure because of external factors such as government expropriation, while women were more likely to feel insecure because of intra-family dynamics and possible limits on the duration of their tenure (Feyertag et al, 2021).

These complex and subtle aspects of the constraints female farmers often face, even if they own the land they cultivate, cannot easily be captured in quantitative analysis but need to be kept in mind when interpreting the results, as we have sought to do in this study. Moreover, women facing production constraints may decide simply to lease out

[3] The situation may be quite different where long-term leases are the norm, for instance in France. Here nine-year leases that are renewed periodically are common and provide tenure security. This was observed especially in the context of group farming (Agarwal, 2019; Agarwal & Dorin, 2018).

their land rather than cultivate it themselves. This aspect of gender disadvantage has not been examined at all in the Indian context, nor did we find any studies on it for other regions.

Overall therefore, empirical work on gender differences in agricultural productivity in Asia (as opposed to Sub-Saharan Africa) is very limited, and that on differences in productivity or in decisions to self-cultivate by the gender of the landowner is non-existent. The absence of data on productivity disaggregated by the gender of landowners has no doubt contributed to this regional research gap, but a further limiting factor is the joint nature of cultivation in Asia, where all family members typically work on all family plots, whereas in Sub-Saharan Africa women usually cultivate separate plots. The sole study on India (Mahajan, 2019) to examine gender differentials in farm productivity focuses on women and men as farm managers and not as owners (likely because of data lacunae), although both are clearly important to test.[4]

The present study seeks to fill these significant gaps in existing research. It uses a unique dataset collected by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) to examine farm productivity by taking into account the gender of the landowner. It also demarcates the effect of caste. And since the data cover nine states, regional differences can also be taken into account. Ours is the first study covering all these aspects in the context of India and Asia.

The paper is divided into six sections. Section 2 discusses existing studies and the data used in this paper. Section 3 describes the characteristics of the owner-cultivators and patterns of decision making. Section 4 provides details of the data, the model for the productivity analysis and the regression results. Section 5 explores whether there are any observable gender differences in the likelihood of landowning households self-cultivating as versus leasing out their land, and Section 6 contains concluding comments.

2 Past studies and current data used

2.1 Past studies on gender and farm productivity

The vast majority of studies relating to gender differences in agricultural productivity, as noted, are on Sub-Saharan Africa. They provide varying results: some find significant differences in productivity between plots managed by men and those managed by women. These differences disappear or decline after controlling for other factors, especially input use. Other studies find no significant gender differences in productivity. The majority of these studies have focused on the gender of the farm manager (or presumed the household head was the manager). Of the nine studies we located which took into account whether the farm managers were also landowners, four found no

[4] In Mahajan's study the farm manager is identified on the basis of the respondent's answer to the question: 'Who is the primary decision maker about farm matters in your house?' Households where farm decision making is joint cannot be identified on this basis.

significant difference in productivity attributable to ownership (Aguilar et al, 2015; Kilic et al, 2013; Palacios-Lopez & Lopez, 2015; Quisumbing et al, 2001), two found owning the land had a positive effect for male farm managers, but an insignificant effect for women (Backiny-Yetna & McGee, 2015; Saito et al, 1994), two found lower productivity in female-owned plots (Alene et al, 2008; Peterman et al, 2011), while one (Gerbe, 2019) found that female owners had higher productivity.

The five Asia-related studies, by contrast, focus on the gender of the manager rather than of the owner. Of these, two (for China and Nepal) found no significant differences between male- and female-managed farms (Zhang et al, 2004; Thapa, 2008), one (for the Philippines) found lower productivity among female-managed farms (Mishra et al, 2017), and two – for South Korea and India – observed mixed effects: Jamison and Lau (1982), who studied South Korea, found no significant difference for non-mechanised farms but higher productivity under male management in mechanised farms, while Mahajan (2019) on India found significantly lower productivity but no significant difference in profitability in female-managed farms relative to male-managed ones. Notably, too, the China and South Korea studies only measured the effect of the gender of the household head. In addition, Agarwal's (2018) paper on India compared all-women group farms with individual family farms (95% of which were male-managed) and found that women's farms had significantly higher per hectare productivity and profits in one state, Kerala, but significantly lower productivity and no difference in profits in another state, Telangana.

None of these studies for Asia, as noted, focused on the effect of women *owning* the land they cultivate. Our study does so. It also captures the effect of caste, which has not been covered in previous studies.

2.2 Data used

The data used in this paper were collected by ICRISAT in India. This is the first time that this data set has been used for tracing the impact of women's ownership of land on farm productivity, although India's ICRISAT data have been used widely for ungendered standard agricultural analysis,[5] and Burkina Faso's ICRISAT data have been used for gender productivity analysis (see, for example, Udry et al, 1995; Akresh, 2008; Bindlish et al, 1993).

The only other study on gender using the ICRISAT dataset for India is that by Agarwal et al (2021a). The authors measured the gender gap in women's ownership of landed property by specifying a wide range of indicators, and examined the factors underlying not only the inter-gender gaps but also the intra-gender gaps, namely the differences between different categories of women and their likelihood of owning land. In contrast,

[5] A large number of development and agricultural economists have used India's ICRISAT data for their analysis (Mullen, 2016), but none has used it for the issues covered in this paper.

our research examines whether there are differences in farm productivity between male and female landowners.

We use the 2014 ICRISAT dataset for India, which was the latest available when this analysis was undertaken. It covers 30 villages located in nine states: Andhra Pradesh, Telangana and Karnataka in south India; Gujarat, Maharashtra and Madhya Pradesh in western and central India; and Bihar, Jharkhand and Odisha in eastern India. Although it covers only nine states, this dataset enables us to identify individually owned and jointly owned plots by gender, gender differences in the amount of land owned and its quality, and the characteristics of the landowners. For the productivity analysis, we merged the land-ownership dataset with that relating to production. We also drew insights from the above-mentioned Agarwal et al (2021a) study, which covers changes in land ownership over the period 2009 to 2014, from the same ICRISAT dataset.

Of the 1114 landowning rural households across the nine states which were the focus of the Agarwal, et al (2021) study, 1025 (92%), had single-sex owners: 89 had only female owners and 936 only male owners, with a few having more than one female or male owner. The remaining 89 households had owners of both sexes, either with women co-owning plots with their spouses or sons, or women and men both owning separate plots within the same household. In Asian farming systems, as noted, women's and men's plots in the same household are not usually managed as distinct entities in terms of input acquisition or other decisions;[6] and many of the plots are also co-owned. Hence, in order to better assess the effect of the landowner's gender on productivity, we based our analysis on a comparison of households with only female landowners and those with only male landowners, omitting the 8% of households with owners of both sexes.

Taking the 1025 landowning households with single sex owners in 2014, there were complete data on land use for 937 households. Of these, 93 were leasing out their land and 10 were growing only perennial crops, leaving 834 that were growing annual crops (see Table 1). We have used these latter households for the productivity analysis. Gender-wise, this gives us 56 female landowner households and 778 male landowner households.

[6] Exceptions include some emerging cases of widows who are cultivating their deceased husband's land and are linked to a self-help group outside the family. Those lacking such links typically manage their plots jointly with plots cultivated by male household heads (personal communication, 23 July 2021, from Seema Kulkarni, General Secretary, MAKAAM, an all-India, informal women farmer's forum, based on her field experience).

Table 1: Household land use by gender of landowners

Land use	All landowner households		Female landowner households		Male landowner households	
	No	**%**	**No**	**%**	**No**	**%**
Total self-cultivators	**834**	**89.01**	**56**	**69.14**	**778**	**90.89**
• Self-cultivating all own land	811	86.55	54	66.67	757	88.43
• Self-cultivating part of own land plus leased-in land; leasing out part of own land	23	2.45	2	2.47	21	2.45
Total leasing out all land	**93**	**9.93**	**25**[b]	**30.86**	**68**	**7.94**
• Leasing out all owned land	62	6.62	21	25.93	41	4.79
• Leasing out part of owned land and leaving rest fallow	31	3.31	4	4.94	27	3.15
Growing only perennials[a]	**10**	**1.07**	**0**	**0.00**	**10**	**1.17**
Complete information	**937**	**100.0**	**81**	**100.0**	**856**	**100.0**
Incomplete information	88	–	8	–	80	–
Total owners	**1025**		**89**		**936**	

Notes: [a] Perennials include tree crops such as coconut, fruit and fodder trees, and sugarcane.
[b] Of these, 16 are in the south, two in the east and none in the west+central region.

In addition, it was notable that 69% of the female landowner households relative to 91% of the male landowner households were self-cultivating (not counting those growing only perennials). Hence a third of the female landowner households were leasing out their owned land relative to only 8% of the male landowner households. To understand if there are any observable factors which can explain these gender differences in land use, we probed further, comparing the self-cultivating households with those leasing out all their land (or part leasing out and leaving the rest fallow). The inability to self-cultivate one's own land can also be seen as an indicator of female disadvantage, attributable to the characteristics of the farm owner, the land owned, or other factors.

3. Owner characteristics and farm decision making

3.1. Characteristics of the owner-cultivators

Do female and male landowner cultivators differ in their individual and household characteristics? Both sexes in our study are on average around 52 years of age, but on other counts there are stark differences (Table 2). First, the average literacy rate among female landowner cultivators is half that among males. Second, 80% of the female landowner cultivators are widowed, relative to only 5% of the males.

Table 2: Demographic features of landowner cultivator households by gender

Features	All landowner cultivator households	Female landowner cultivator households	Male landowner cultivator households
Number of observations	834	56	778
	Owner characteristics		
Age of owners (mean yrs) [a]	51.79	52.28	51.75
Education of owners[a]			
• % literate owners	70.14	37.5	72.50
Caste of owners			
• % Upper caste	23.26	17.86	23.65
• % OBCs	36.93	26.78	37.66
• % SC and other	39.81	55.36	38.69
Marital status of owners[a]			
• % Married	89.81	19.64	94.86
• % Widowed/single[b]	10.19	80.36	5.14
	Household characteristics		
Number of persons aged ≥15 in HH	4.14	3.93	4.15
Number of males aged ≥15 in HH	2.17	1.68	2.20
Land owned by caste (ha)			
All households	1.66	1.44	1.68
• Upper caste	2.11	1.74	2.13
• OBC	1.75	2.44	1.72
• SC and others	1.32	0.85	1.37

Notes: HH = household, OBC = Other Backward Castes; SC = Scheduled Caste.
[a] In HHs with more than one landowner, the characteristics of the owner who was also the HH head were taken.
[b] The female landowners are all widows, while male landowners include widowers and 0.9% unmarried or separated males.

Table 3: Asset ownership among landowning households

Assets owned	Female landowner HHs		Male landowner HHs	
	Self-cultivators (56)	Lessors (25)	Self-cultivators (778)	Lessors (68)
	Percentage and number of households owning given asset			
Tractor	3.6 (2)	(0)	4.6 (36)	(4)
Power tiller	0.0 (0)	(0)	0.8 (6)	(1)
Seed drill	14.3 (8)	(0)	23.5 (183)	(3)
Power spray	7.1 (4)	(0)	7.0 (55)	(0)
Manual spray	7.1 (4)	(3)	29.6 (230)	(15)
Drip irrigation	3.6 (2)	(0)	4.9 (38)	(2)
Electric motor	16.1 (9)	(0)	28.2 (219)	(13)
Diesel motor	10.7 (6)	(3)	19.2 (149)	(8)
Submersion pump	10.7 (6)	(6)	19.8 (154)	(10)

Note: Figures in brackets give the number of cases.

None of the women landowners have young children (≤ 5 yrs), but, in general, landowning widows tend to be disadvantaged in farm management in terms of limited family support and restrictive social norms (Kulkarni et al, 2021). Relative to male landowner households, female landowner households also comprise fewer persons and fewer males aged 15 or over who could work on the farm. Third, the female landowner cultivators are predominantly members of a Scheduled Caste (SC), while the male landowner cultivators are much more evenly spread across caste groups. The reason for this appears to lie in the much larger proportion of upper-caste female landowners relative to upper-caste male landowners leasing out their land rather than cultivating it themselves (as discussed below). SC households also own less land on average relative to other castes.

Ownership of farm implements can be another inequality. Notably, women landowner households own fewer farm implements of all types, and especially tractors and power tillers (Table 3). This has also been noted in other countries (FAO, 2011) and it makes women farmers more dependent than males on hired machines for key operations like land preparation, while hiring tractors involves higher transaction costs for women than men.

3.2 Decision making

Farm productivity also depends on management decisions. Most studies assume that the household heads are the main decision makers in farm-related decisions and hence are the farm managers. This could be a fair assumption where ownership and headship overlap but it is not perfect, given the complexity of decision making in farm households. Typically studies have failed to examine joint decision making. Mahajan's (2019) study, based on data from the Indian Human Development Survey (IHDS), also fails to capture this complexity, since only one question was asked in the Survey: 'Who is the primary decision maker about farm matters in your house?'

In our data, among the cultivating households, 99% of the male landowners and 82% of the women landowners are also household heads. But are they making the decisions? The ICRISAT data on decision making simply tell us if the decision maker is male or female but not the identity of the decision maker, viz whether the person is the owner or the household head. We mapped the gender of the decision maker by household land ownership on five input-related decisions for which there were data, and found that the main decision makers varied by type of input (Table 4). Labour-related decisions were joint in 58%–60% of both female and male landowner cultivator households. For other inputs, in male owner households decisions were made by men alone or jointly with women but rarely by women alone, while in female owner households, although women alone made decisions in about a quarter of the cases, men were very involved as joint decision makers or even as sole decision makers.

Overall, therefore, it is difficult to say categorically who is the principle decision maker for the farm as a whole. What we do know is that male land ownership, male headship and male decision making overlap in very large part but, in female landowner cultivator

households, although ownership and headship largely overlap, decision making is more diverse.[7]

For our regression analysis we therefore created a dummy for households where the landowner was not involved in even one of the five decisions.[8] There were only 11 such cases (seven for female owner households, four for male owner households). We have not seen this variable used before; hence, despite the small number of cases, we tested it (interchangeably with headship) for the pooled sample and female owners, to see if it affected output. Of course, the results can at best be seen as indicative.

Table 4: Decision makers by inputs in landowner cultivator households

Inputs	All owner cultivator HHs (884)			Female owner cultivator HHs (56)			Male owner cultivator HHs (778)		
	Who makes the decision for given inputs? [a] Percentages								
	F	M	B	F	M	B	F	M	B
Fertilisers	3.7 (30)	65.2 (528)	31.1 (252)	23.2 (13)	33.9 (19)	42.9 (24)	2.3 (17)	67.5 (509)	30.2 (228)
Pesticides	2.4 (19)	76.3 (609)	21.3 (170)	17.3 (9)	48.1 (25)	34.6 (18)	1.3 (10)	78.3 (584)	20.4 (152)
Seeds	2.7 (22)	58.0 (472)	39.3 (320)	23.2 (13)	26.8 (15)	50.0 (28)	1.2 (9)	60.3 (457)	38.5 (292)
Hired labour	7.6 (60)	31.4 (248)	61.1 (483)	24.5 (13)	17.0 (9)	58.5 (31)	6.4 (47)	32.4 (239)	61.2 (452)
Own labour	10.3 (85)	29.5 (243)	60.1 (495)	21.8 (12)	20.0 (11)	58.2 (32)	9.5 (73)	30.2 (232)	60.3 (463)

Note: [a] Figures in brackets give number of cases with information and the percentages relate to cases with information.
HH = household. F = female only; M = male only; B = both male and female.
The data only mention whether the decision is made by a male or a female and do not specifically identify whether that person is the landowner.

4 Gender differences in input use and productivity

We now consider gender differences in input use by gender of land ownership in the cross-tabulations, followed by our regression model and results for productivity.

4.1 Input use: cross-tabulations

Table 5 cross-tabulates the values of output produced and inputs used by female and male landowner cultivator households. We calculated *t*-tests of difference in means for relevant variables by using log values in a regression function. We find that the two sets of households do not differ significantly in terms of output per hectare of gross cropped area (GCA). This is notable, since this holds without controlling for input use or

[7] Of the ten households of women owners with male heads, both genders were involved in most decisions in seven cases, while in three cases the decision maker was a male alone.
[8] We arrived at this as follows: in female landowner households these were cases where all decisions were being taken by a male; the reverse was true in male landowner households.

other factors. Nor do female and male landowner cultivators differ significantly in the use of most inputs, such as fertilisers, labour, extent of irrigation or soil quality. However, male landowner cultivators do have significantly higher use of pesticides and tractors/power-tillers, and the upper end of the range of their average GCA is much higher and the *t*-values are significant.

Table 5: Output and inputs in landowner cultivator households: cross-tabulations

Variable	**All owner cultivator households**	**Female owner cultivator households**	**Male owner cultivator households**	***t*-values of difference in means** Regressing on log values
1	**2**	**3**	**4**	**5 = 3 - 4**
No of observations	834	56	778	
Total value of output /GCA	49003.15	51963.46	48790.06	-1.31
GCA per ha	1.97	1.97	1.97	-1.85*
• GCA/ha range	0.008 – 56.66	0.06-34.80	0.008-56.66	
Value of fertiliser/GCA	6340.17	8063.80	6216.10	0.83
Value of pesticide/GCA	885.83	690.50	899.89	-2.52**
Tractor hrs/GCA	12.75	5.85	13.24	-1.78*
Labour hrs/GCA	432.97	584.96	422.03	0.57
% GCA irrigated area	28.14	29.77	28.03	0.31
% GCA with non-problem soil	95.22	92.28	95.43	-0.94
% GCA under food grains	74.10	77.89	73.82	0.83

Note: GCA= gross cropped area.

The significantly lower use of tractors in female landowner households needs elaboration. As noted earlier, hardly any of these households own tractors or power tillers and most depend on hiring the machines. Although we lack qualitative evidence from the ICRISAT dataset, analysis by other authors has shown that women in general, and SC women in particular, face much greater difficulty than men in hiring tractors and even in obtaining other inputs in time.

For example, Agarwal's (2020, 2018) research on SC women farming in groups in Telangana, illustrates women's experiences:

> "We don't get tractors, fertilisers and pesticides in time. Those who lease out tractors for ploughing only come to our land after completing the work of the big farmers." (Women's group farm members, Kalwal village, Mahbubnagar district, Telangana)

> "In the entire village there are only two tractors and everyone needs the tractor in time. The tractor owner is reluctant to plough [our] land and we have to pay several visits to bring him to our land. Moreover, apart from the general hiring price, the tractor driver demands toddy [local liquor] and Rs 50 extra for breakfast." (Women's group farm members, Ibrahimbad village, Mahbubnagar district, Telangana)

> "[In] the peak season, getting a tractor is not easy. We are charged high rates – Rs1200 per hour or more – and these [male] tractor owners keep changing the price according to demand and season. We are also made to wait 2–3 days." (Women's group farm members, Kondapur village, Karimnagar district)

Timely completion of operations, especially land preparation, can make an important difference to productivity, especially where gender and caste disadvantages overlap.

These women also complained about the difficulties of getting seeds and fertiliser:

> "Yes we have a problem in getting good quality seeds. To some extent, the whole village faces this problem, but women face it more. Moreover, for getting one bag of fertiliser we have to queue in long lines for an entire day, and that is very difficult for women." (Women's group farm members, Kondapur village, Karimnagar district)

Given women's domestic work responsibilities, standing in long lines for procuring inputs stretches their work day into longer hours. This is usually an invisible cost which may not show up in actual input use or productivity.

We also compared labour use by female and male owner-cultivator households in some detail (Table 6). Overall, female owner households used more labour time per hectare (but the difference, as noted above in Table 5, is not statistically significant). There are, however, notable differences in the types of labour used. For example, female owner-cultivators relative to male owner-cultivators use a larger proportion of female than male labour time overall. They are also much more dependent on family and exchange labour,[9] and especially on female family and female exchange labour. Some 54% of the female labour used by female landowners is family labour, while a larger proportion of female labour used by male landowners is hired, and very little is exchange labour.

These observed gender differences in personal characteristics and access to some key inputs point to an unequal playing field for women owner-cultivators. However, this may or may not show up in productivity differences with male owner-cultivators, since some of these gender disadvantage can be overcome by the presence of male support

[9] Exchange labour is labour exchanged between households. For example if household A provides labour to household B, household B in exchange will provide labour to household A. Usually female labour is exchanged with female labour and male with male, or by converting them (imperfectly) into equivalent units.

(virtually all the female landowner cultivator households have family males aged ≥15), and some costs, such as the stretching of women's time in procuring inputs, may remain hidden.

Table 6: Labour use disaggregated by gender and type in landowner cultivator households

Labour category	Female owner cultivator households Mean (56)	Male owner cultivator households Mean (778)
Total labour hours	**584.96 (100.00)**	**422.03 (100.00)**
Male	257.76 (44.1)	204.52 (48.5)
Female	324.87 (55.5)	215.72 (51.1)
Child	2.32 (0.4)	1.79 (0.4)
Family	**407.83 (58.8)**	**268.42 (63.6)**
• Male	230.85 (56.6)	168.78 (62.9)
• Female	174.72 (42.8)	98.03 (36.5)
• Child	2.25 (0.6)	1.60 (0.6)
Hired	**134.52 (37.7)**	**146.79 (34.8)**
• Male	23.73 (17.6)	33.75[a] (22.9)
• Female	110.72 (82.3)	113.09 (77.0)
• Child	0.07 (0.05)	0.18 (0.1)
Exchange	**42.61 (3.6)**	**6.60 (1.6)**
• Male	3.18 (7.5)	1.99 (30.2)
• Female	39.43 (93.5)	4.60 (69.7)
• Others (child)	0.00	0.01 (0.2)

Note: Figures in brackets are percentages calculated from the mean hours for the whole sample.
[a] Includes 0.23 hours of permanent hired labour.

4.2 Regression model for the productivity analysis

To estimate productivity differences, we computed the following three equations. Equation (1) contains all landowning cultivator households; equation (2) contains only female landowner cultivator households, and equation (3) only male landowner cultivator households. The basic unit of analysis is the landowning household.

(1) $log(Y) = \beta_0 + \beta_1 d_{gowner} + \sum_j \alpha_j log(W_j) + \sum_k \gamma_k Z_k + \beta_2 X_{irr} + \beta_3 X_{soil} + \beta_4 X_{fg} + \beta_5 d_{dec} + \beta_6 d_{lit} + \beta_7 d_{uc} + \beta_8 d_{obc} + \beta_9 d_{south} + \beta_{10} d_{west+central} + \varepsilon$

(2) $log(Y) = \beta_0 + \sum_j \alpha_j log(W_j) + \sum_k \gamma_k Z_k + \beta_1 X_{irr} + \beta_2 X_{soil} + \beta_3 X_{fg} + \beta_4 d_{dec} + \beta_5 d_{lit} + \beta_6 d_{uc} + \beta_7 d_{obc} + \beta_8 d_{south} + \beta_9 d_{west+central} + \varepsilon$

(3) $log(Y) = \beta_0 + \sum_j \alpha_j log(W_j) + \sum_k \gamma_k Z_k + \beta_1 X_{irr} + \beta_2 X_{soil} + \beta_3 X_{fg} + \beta_4 d_{lit} + \beta_5 d_{uc} + \beta_6 d_{obc} + \beta_7 d_{south} + \beta_8 d_{west+central} + \varepsilon$

Where Y = annual value of output per gross cropped hectare cultivated by the household

d_{gowner} = gender of landowner dummy (female landowner household = 1; male landowner household = 0)

W_j = inputs: gross cropped area (GCA) in hectares, value of fertilisers+manure/GCA, value of pesticides/GCA, labour hrs/GCA, tractor/power-tiller hrs/GCA. Here j connotes the jth input

$Z_{k=}$ labour type variables: % male labour hours; % hired labour hours. Here k connotes the kth type of labour

X_{irr} = percentage GCA irrigated

X_{soil} = percentage GCA without problem soil

X_{fg} = percentage GCA under food grains

$d_{dec=}$ dummy for farm decision maker (no decision by landowner = 1; 0 otherwise)

d_{lit} = dummy for literacy (if landowner is literate = 1; 0 otherwise)

d_{uc} , d_{obc} = caste dummies (caste of the landowner). Ref category = SC and others

d_{south}, $d_{west+central}$ = regional dummies (landowner household location). Ref category = east

In all the equations, robust standard errors clustered at the village level are reported.

The dummy for the landowner's gender in equation (1) helps us assess whether female land ownership makes a difference to overall agricultural productivity, controlling for input use, landowner and household characteristics, and the household's regional location. Equations (2) and (3) then assess whether the factors that affect farm productivity differ between female owner cultivator households and male owner cultivator households.

We expect the gender of the landowner to make a difference in terms of the ability to procure inputs and hired labour as well as exercise command over male family labour. As noted, women landowners could be at a disadvantage in this respect, which can affect crop output. In equation (2) we drop the gender dummy, but include the dummy for the landowners making no production decisions. Interchangeably we also tried the gender of the household head. In equation (3) we do not use either the headship or the no-decision dummy, given the very high overlap between male land ownership, male headship and male decision making, and the very few (only four) cases of no-decision by the owner.

We also assess the effect of the demographic characteristics of the landowners, such as their literacy and caste. We tried testing for age and marital status as well, but these

were consistently insignificant across all models and have therefore not been reported in the regression tables. For marital status, as noted, the vast proportion of female landowners are widows and the vast proportion of male landowners are married. In the caste dummies, 95% of the reference caste households are Scheduled caste, the remaining being largely Scheduled Tribe and Christians. Located in Jharkhand and Orissa, it is quite likely that the Christians too were formerly from tribal communities.

We use broad regional dummies to distinguish between households located in south India, west+central India and eastern India. These regions differ broadly in their local ecology, cropping patterns and extent of agricultural commercialisation (on this, see also Agarwal & Agrawal, 2017).

4.3. Productivity results

Table 7 and Appendix Tables A1, A2, and A3 respectively present our regressions results and descriptive statistics for farm productivity. In the pooled regression (equation 1), our variable of particular interest is the gender of the landowner. We find no statistically significant productivity difference between female landowner and male landowner households. Most of the input variables are positive and significant but the most notable contributor to output is labour time, with a 1% increase in labour time linked to a 0.44% increase in annual value of output per hectare.

Caste also matters: upper-caste households have the highest productivity, followed by OBC households, both of which do better than SC households. In equation 1 we also tried interacting the gender and caste dummies but the results were not statistically significant, and these results have not been included in the table.

Regionally, the eastern states do better than both the west+central and southern states, but the latter two regions do not differ much from one another.

Notably, our dummy for no-decisions by the landowner is negatively significant. This suggests that the non-involvement (possibly exclusion) of the owner from all five farm-related decisions can have a negative effect on productivity. Since there are only 11 such cases, our results are only indicative, but nevertheless interesting. We also tried gender of household head, but this was insignificant.

Among female landowners (equation 2), the input variables of particular note are labour time (a 1% increase in labour hours per hectare is linked with a 0.50% increase in annual value of output per hectare), followed by tractor/power-tiller hours, pesticide use, and percentage area under no-problem soil. However, it is the caste and no-decision variables which again warrant particular comment. Being upper-caste gives women an advantage relative to women in both OBC and SC households. For example, upper-caste female owners are found to have a 143% higher annual value of output per hectare than SC female owners.[10]

[10] This figure was arrived at as follows: $(e^b - 1) * 100$, where b is the coefficient of the dummy variable.

Table 7: Factors affecting productivity by gender of landowner in landowning cultivator households, 2014

	Landowner cultivator households		
	All owner households	Female owner households	Male owner households
Dependent variable	Log annual value of output (Rs/ha)		
Equation number	1	2	3
No of observations	834	56	778
R^2	0.4836	0.6215	0.4959
Explanatory variables	**Coef**	**Coef**	**Coef**
Gender of owner (dummy: female =1)	0.004 (0.978)	---	---
Log gross cropped area (ha)	0.054 (0.197)	-0.109 (0.575)	0.073* (0.080)
Log fertiliser value/GCA (Rs/ha)	0.058* (0.074)	-0.056 (0.679)	0.064* (0.050)
Log pesticide value /GCA (Rs/ha)	0.044 (0.126)	0.178** (0.017)	0.033 (0.193)
Log tractor hours /GCA (hrs/ha)	0.157*** (0.002)	0.313* (0.081)	0.147*** (0.002)
Log labour hrs/GCA (hrs/ha)	0.435*** (0.000)	0.495** (0.044)	0.430*** (0.000)
% Male labour	0.004 (0.130)	-0.008 (0.461)	0.004 (0.113)
% Hired labour	-0.001 (0.497)	-0.011† (0.102)	-0.001 (0.669)
% GCA irrigated	0.002* (0.082)	0.006 (0.251)	0.002* (0.081)
% GCA without problem soil	0.009* (0.075)	0.011* (0.073)	0.009* (0.049)
% GCA under food grains	-0.005* (0.049)	0.007 (0.207)	-0.006** (0.019)
Irrigation machine owned dummy (machine owned =1)	0.167* (0.072)	0.547 (0.136)	0.152* (0.091)
Owner takes no production decisions dummy (no decision =1)	-0.593** (0.018)	-0.997** (0.037)	----
Literacy dummy (if owner is literate=1)	-0.046 (0.452)	-0.131 (0.696)	-0.032 (0.621)
Upper caste dummy (if owner is upper caste=1)	0.322** (0.011)	0.890** (0.044)	0.327** (0.011)
Other Backward Castes (OBC) Dummy (if owner is OBC=1)	0.228* (0.081)	0.002 (0.994)	0.266** (0.039)
Regional dummy 1 (if south =1)	-0.441** (0.035)	-0.396 (0.469)	-0.416** (0.032)
Regional dummy 2 (if west+central =1)	-0.507** (0.012)	-0.365 (0.451)	-0.500** (0.008)
Constant	6.500	6.000	6.510

Source: Calculated by the authors from ICRISAT data.

Notes: Numbers in brackets are *p*-values. Significance: † close to 10%; *10%; **5%; ***1 %.
In all the equations robust standard errors clustered at the village level were computed. Without village-level clustering, pesticide use and % male labour were also statistically insignificant in equations 1 and 3, the other variables remaining the same in terms of significance.
Reference categories
For regions: eastern states. For caste: SC (mainly) and some others.
Differences between included dummies
Regions: None of the equations shows a significant difference between the west+central region and the south.
Caste: Equations 1 and 3 show no significant difference in productivity between upper castes and OBCs. In equation 2 for women, upper castes have significantly higher productivity than the OBCs at the 10% level.

Also worth noting is the negative sign and significance of the no-decision-making owners, although, as in equation 1, given the small number of such households, this is only indicative. It would be worth examining using other datasets.

The results for the male landowner households (equation 3) are very close to the pooled sample, not surprisingly since they constitute a large proportion of the pool. Most of the input variables are significant but labour again contributes the most. A 1% increase in labour hours per hectare leads to a 0.43% increase in the annual value of output per hectare. Tractor/power-tiller hours and farm size are also linked with higher productivity. Farmers devoting more of their land to foodgrains, however, do worse than those focused more on non-food crops. This has also been noted in other studies on India (see, for example, Agarwal, 2018; Mahajan, 2019). As with female landowners, caste matters, with upper-caste male owners again doing best, followed by OBCs, and then SCs and others. Notably too, the non-eastern states perform worse than the eastern states.

The consistently poorer performance of SC households relative to upper-caste households in all the equations is likely to be linked to several disadvantages faced by the SCs which cannot be measured directly through our data, but for which there is substantial evidence from other studies. Such disadvantages include SC members' poorer access to funds, especially via formal credit institutions and lower access to extension information, as well as their limited social networks, constituted mainly of the disadvantaged. In national-level studies in India, for instance, SC households are found to be discriminated against when seeking agricultural credit from cooperative banks (Kumar, 2013). They also tend to have a narrower range of social networks which can affect timely access to hired labour (Nandi, 2010), as well as less access farm machinery, especially tractors (Agarwal, 2020), and agricultural extension information (Krishna et al, 2019). These disadvantages, is turn, affect agricultural productivity and returns (Rao, 2017).

On all these counts, women from SC households face an additional gender disadvantage (Kumar, 2013; Agarwal, 2020). As noted earlier, both gender and caste can play out in hiring tractor services and getting inputs, with SC women being much worse off than upper-caste women, as well as relative to men more generally.

5 Self-cultivation versus leasing out

Gender differences between landowners also come into play in decisions on whether to cultivate the land oneself, lease it out, or keep it fallow. This is an aspect on which we have seen no prior study, either for India or other regions.[11]

As noted in Table 1, a third of female landowners lease out their land relative to 8% of male landowners. What factors are linked to this decision? It should be noted that what we see is the end result of supply and demand factors operating in the land-lease market.

5.1 Characteristics of owner-cultivators and lessors

Potentially, several types of factors can affect the decision to cultivate or lease out. One set of factors would relate to the land owned: its area and whether it is irrigated. A second set could relate to labour concerns such as the availability of family labour, especially male labour, which could matter to female owner households in particular. A third set of factors can relate to the characteristics of the owners – their age, literacy, marital status (older people and widows tend to be more vulnerable) and caste. Fourth, region can matter in terms of the demand for leased land.

A cross-tabular comparison of female self-cultivating landowners with those who are leasing out their land shows similarity in terms of their average age, literacy and marital status (80% were widowed),[12] but differences in several other respects (Table 8). Those leasing out, for example, have more land on average and a larger percentage own irrigation pumps,[13] but they have fewer family members aged ≥15: in fact, 32% have no males aged 15 or over in their household, relative to only 5% among the self-cultivators. It is striking too that lessors are located substantially in the southern states. The self-cultivators have more family labour and more male family labour at their command than those leasing out. In addition, OBCs are in much greater proportion among the owner-cultivators than the lessors.

Among male landowners, differences between self-cultivators and lessors are more pronounced: those leasing out are older, have higher levels of literacy, own more land with a larger proportion that is irrigable, and less family labour in their households. Similar to female landowners, male self-cultivators are more commonly OBC or SC but, unlike for female landowners, a much larger proportion of male self-cultivators relative to those leasing out own irrigation equipment.

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[11] Goldstein and Udry (2008), do examine the effect of tenure security on decisions to practice fallowing in Ghana, but here fallowing is seen as a way of improving land fertility rather than as necessitated by possible production constraints. They do not examine leasing out as an option.
[12] Having small children (say under 5 years) could also matter for female owners, but we found only two female owners with children aged 5 or below. Most were grandmothers.
[13] Irrigation is largely through groundwater (via borewells or open wells), with some use of canals, tanks or rivers. Some farms have more than one irrigation source.

These factors are examined further in our regression analysis to see if they affect a landowners's decision to self-cultivate or lease out the land.

Table 8: Self-cultivators vs lessors: characteristics

Variable	Female landowner households		Male landowner households	
	Self-cultivating (56)	Leasing out (25)	Self-cultivating (778)	Leasing out (68)
Total area owned (ha)	1.44	1.75	1.68	2.01
% owned area that is irrigable[a]	47.6	41.40	51.6	59.52
% Ownership of irrigation machines[b]	28.57	36.00	52.83	32.35
% literate[c]	37.50	36.00	72.49	83.82
Age of owner (years) [c]	52.29	52.64	51.76	56.38
Marital status dummy (widowed=1)	80.36	80.00	4.24	4.41
Number of household members $\geq$ 15 years	3.93	2.40	4.15	3.71
Number of male members $\geq$ 15 years	1.66	0.76	2.17	1.90
% HHs with no male members $\geq$ 15 years	5.36	32.0	0.00	0.00
% Upper-caste owners	17.86	24.00	23.65	38.24
% OBC owners	26.79	16.00	37.66	22.06
% SC owners	55.36	60.00	38.69	39.71
% in south	19.64	68.00	20.44	35.29
% in west+central and east	80.36	32.00	79.56	64.71

Notes: [a] The irrigable area tends to be higher than the area actually irrigated.
[b] The machines include electric or diesel pumps, submersion pumps and drip irrigation equipment.
[c] In households with more than one owner, we have taken the characteristic of the owner who was also the household head.

5.2 Regression model for self-cultivation

We ran a logistical regression to compare self-cultivating and non-cultivating households who were leasing out. We computed the following equations:

(1) $d_{self\text{-}c} = \beta_0 + \beta_1 d_{gowner} + \beta_2 X_{land} + \beta_3 X_{irr} + \beta_4 d_{irrM} + \beta_5 X_{HH\ persons} + \beta_6 X_{age} + \beta_7 d_{lit} + \beta_8 d_{uc} + \beta_9 d_{obc} + \beta_{10} d_{south} + \varepsilon$

(2) $d_{self\text{-}c} = \beta_0 + \beta_1 X_{land} + \beta_2 X_{irr} + \beta_3 d_{irrM} + \beta_4 X_{HH\ persons} + \beta_5 X_{age} + \beta_6 d_{lit} + \beta_7 d_{uc} + \beta_8 d_{obc} + \beta_9 d_{south} + \varepsilon$

(3) $d_{self\text{-}c} = \beta_0 + \beta_1 X_{land} + \beta_2 X_{irr} + \beta_3 d_{irrM} + \beta_4 X_{HH\ persons} + \beta_5 X_{age} + \beta_6 d_{lit} + \beta_7 d_{uc} + \beta_8 d_{obc} + \beta_9 d_{south} + \varepsilon$

Where $d_{self\text{-}c}$ = cultivating dummy (self-cultivating household = 1, leasing out = 0)

d_{gowner} = gender of landowner dummy (female landowner household = 1)

X_{land} = area owned (ha)

X_{irr} = percentage area owned that is irrigable

d_{irrM} = dummy for irrigation machinery owned (if owned = 1)

HH persons = number of persons in the household ≥15 years of age

X_{age} = age of landowner in years

d_{lit} = dummy for literacy (if owner is literate = 1)

d_{uc} , d_{obc} = caste dummies

d_{south} = regional dummy (south = 1, other regions = 0)

Given the small number of married women landowners and (similarly) the small number of widowed male landowners, we have not used the marital status variable in the regressions.[14] Regionally, 68% of female owners who leased out their land were located in south India and there was only one such case in eastern India. Hence we have clubbed east India together with west+central to create one regional dummy, with regions other than the south as the reference category.

In all the equations, robust standard errors clustered at the village level have been computed.

5.3 Self-cultivation results

Overall, for all landowning households pooled together, we find from the marginal effects (ME) that the probability of women landowners self-cultivating their land is 16.5 percentage points lower than for male owners (Table 9, equation 1; for descriptive statistics see Table A4). In fact, gender is the most important factor explaining leasing out along with regional location. Landowner households based in the south are 11.4 percentage points less likely to self-cultivate that those in other regions. In addition, lessors are more likely to be owners with more land, more irrigable area, older, and literate. In contrast, those belonging to the OBC caste group are found much more likely to self-cultivate than other castes, as are those with more family members aged 15 or over,[15] and those owning irrigation equipment such as pumps.

For female landowner households, the most important factor increasing the probability of self-cultivation, apart from being located in the non-southern states, is found to be the number of household members aged ≥15. Every additional member aged ≥15

[14] We did try widowhood in trial runs, but it was insignificant.
[15] The phenomenon of older landowners leasing out their land is also seen in other countries, such as Romania, something further exacerbated by a generational shift, with younger family members moving out of farming (Agarwal et al, 2021b).

increases the likelihood of self-cultivation by 16.7 percentage points. In other words, access to labour is key and its absence can be a major constraint. In fact, some 13.6% of the female landowner households have no male members aged ≥15 and most of them are leasing out their land.

Table 9: Likelihood of self-cultivation vs leasing out owned land by gender of landowner, 2014 (logistic regressions)

Dependent variable	**Self-cultivating households (dummy: self-cultivator = 1)**		
	All landowner households	**Female landowner households**	**Male landowner households**
Equation number	1	2	3
No of observations	927	81	846
Pseudo R^2	0.1896	0.3656	0.1444
Explanatory variables	**ME**	**ME**	**ME**
Gender of owner (female=1)	-0.165** (0.006)	---	---
Area owned (ha)	-0.007*** (0.001)	0.008 (0.556)	-0.006*** (0.001)
% owned area that is irrigable	-0.001** (0.009)	-0.001 (0.430)	-0.001*** (0.000)
Irrigation machine owned dummy (machine owned=1)	0.073*** (0.001)	0.047 (0.743)	0.083*** (0.000)
Number of HH members aged ≥ 15	0.016** (0.044)	0.167*** (0.000)	0.010* (0.086)
Literacy dummy: owner is literate=1	-0.037*** (0.005)	-0.050 (0.768)	-0.036*** (0.002)
Age of owner (years)	-0.002** (0.012)	-0.008* (0.054)	-0.002** (0.012)
Caste dummy 1: owner is upper caste =1	-0.040 (0.167)	-0.343 (0.207)	-0.028 (0.198)
Caste dummy 2: owner is OBC =1	0.036** (0.012)	0.055 (0.525)	0.030** (0.030)
Regional dummy: south = 1	-0.114*** (0.000)	-0.465*** (0.000)	-0.074*** (0.001)

Source: Calculated by the authors from ICRISAT data.
Notes: In all the equations robust standard errors clustered at the village level are reported.
ME = marginal effects. Numbers in brackets are *p*-values. Significance: *10%; **5%; ***1 %.
Differences between included dummies
Caste: in equations 1 and 3 the OBCs are significantly more likely to self-cultivate than the upper castes; significance at the 1% level. In equation 2 the difference is not significant.

Male landowner households, in contrast, follow the same pattern as the pooled sample. They are more likely to lease out when they own more land, especially if irrigable, while owning irrigation pumps has the opposite effect. Leasing out irrigable land is, at one level, surprising, since we would expect farmers to self-cultivate such land. It is likely that the demand side of the land-lease market is playing a role here, with farmers more likely to find lessors for irrigable land, especially in south India where paddy cultivation dominates and land with irrigation would be in high demand. In any case, the irrigable

area variable is tempered by ownership of irrigation equipment. Also older, literate, upper-caste male farmers are less likely to self-cultivate: it is possible that they have non-farm income sources, but we lack reliable data to check this.

The three factors that are consistently significant across all the equations and across gender, in terms of the probability of leasing out, are a family labour constraint, being based in south India and the owner being old.

6 Concluding comments

Global evidence on gender differences in agricultural productivity is sparse, and most of it relates to the gender of the cultivator rather than that of the landowner. Also, barring a few exceptions, almost the entire body of work on both counts relates to countries in Sub-Saharan Africa. This evidence, variously controlling for input use, shows mixed effects in terms of the impact of gender on agricultural productivity, some studies finding lower productivity on women's farms, others showing a neutral effect, and a rare one finding higher productivity.

In the case of Asia, not only are there very few studies on productivity differences by gender, but none takes into account the effect of the farmer owning the land s/he cultivates. Also, none examines leasing out land rather than self-cultivating it, which can indicate gender disadvantage. Moreover, in the Indian context, the intersectionality of gender and caste matters. This paper has broken new ground in covering all these aspects, especially in the context of Asia and India.

We find that the gender of the landowner is not a statistically significant factor in explaining differences in farm productivity, with or without controlling for input use and owner and household characteristics. However, caste emerges as a key factor. SC farmers face a substantial disadvantage and have significantly lower per hectare productivity than upper-caste farmers. This holds for both female and male landowners. Over half the female landowner households who are cultivating belong to the SC relative to 39% of male owner-cultivators. Hence, although the direct effect of gender is limited, when linked with caste it can make for a notable combined disadvantage.

Moreover, gender emerges as important in decisions to self-cultivate or lease out owned land. Women landowners are significantly more likely to lease out their land than male landowners. The availability of family labour in terms of members aged 15 or more is significantly and positively related to self-cultivation among both female and male landowners. Older owners of both genders are, however, more likely to lease out. Much of the leasing out takes place in south India. The finding that those with a higher percentage of irrigable land are more likely to lease out suggests that the demand side of the lease market impinges on these decisions.

Finally, our results point to the special need to support SC women farmers. Here, institutional innovations, such as group farming by women, could also provide a way

forward, as demonstrated by Agarwal's (2018) findings for south India and Sugden et al's work (2021) on eastern India. Farming in groups has enabled women in these regions to overcome many of the production constraints, especially the labour constraints that they tend to face as individual farmers.

References

Alene, A.D., Manyong, V.M., Omanya, G.O., Mignouna, H.D, Bokanga, M. and Odhiambo, G.D. (2018). 'Economic efficiency and supply response of women as farm managers: comparative evidence from western Kenya'. *World Development 36*, 1247–1260.

Agarwal, B. (2020). 'Does group farming empower rural women? Lessons from India's experiments'. *Journal of Peasant Studies 47*, 841–872.

Agarwal, B. (2019). Group Farming and Collective Action: Does the French Model hold Lessons for Indian and French Farming Futures? Final Report of Project 4001-GF submitted to CEFIPRA, New Delhi.

Agarwal, B. (2018). 'Can group farms outperform individual family farms? Empirical insights from India'. *World Development 108*, 57–73.

Agarwal, B. (2014). 'Food security, productivity and gender inequality'. In Herring, R. (ed.), *Handbook of Food, Politics and Society*. New York*:* Oxford University Press.

Agarwal, B. and Agrawal, A. (2017). 'Do farmers really like farming? Indian farmers in transition'. *Oxford Development Studies 45*, 460-478.

Agarwal, B. and Dorin, B. (2018). 'Group farming in France: why do some regions have more cooperative ventures than others?' *Environment and Planning A: Economy and Space 51*, 781–804.

Agarwal, B., Anthwal, P. and Mahesh, M. (2021a). 'How many and which women own land in India: intra-gender and inter-gender gaps'. *Journal of Development Studies*, April. https://doi.org/10.1080/00220388.2021.1887478

Agarwal, B., Dobay, K.M. and Sabates-Wheeler, R. (2021b). 'Revisiting group farming in a post-socialist economy: the case of Romania'. *Journal of Rural Studies 81*, 148–158.

Aguilar, A., Carranzab E., Goldstein, M., Kilic, T. and Osenid, G. (2015). 'Decomposition of gender differentials in agricultural productivity in Ethiopia'. *Agricultural Economics*, *46*, 311–334.

Akresh, R. (2008). '(In)efficiency in intrahousehold allocations'. Working Paper, Dept. of Economics, University of Illinois at Urbana Champaign.

Backiny-Yetna, P. and McGee, K. (2015). *Gender Differentials and Agricultural Productivity in Niger*. Policy Research Working Paper WPS7199.Washington DC: World Bank.

Berger, M., DeLancey, V. and Mellencamp, A. (1984). 'Bridging the gender gap in agricultural extension'. Paper prepared for the Office of Women in Development, US Agency for International Development (USAID), Washington DC.

Bindlish,V., Evenson, R. and Gbetibouo, M. (1993). 'Evaluation of T and V-based extension in Burkina Faso.' World Bank Technical Paper No. 226, Africa Technical Department Series, World Bank, Washington, DC.

Deininger, K. and Chamorro, J.S. (2004). 'Investment and equity effects of land regularisation: the case of Nicaragua'. *Agricultural Economics 30*, 101–116.

Deininger, K. and Feder, G. (2009). *Land Registration, Governance, and Development: Evidence and Implications for Policy*. Working Paper 2. Washington DC: World Bank Research Observer.

Deininger, K. and Jin, S. (2006). 'Tenure security and land-related investment: evidence from Ethiopia'. *European Economic Review 50*, 1245–1277.

Doss, C.R. (1999). *Twenty-five Years of Research on Women Farmers in Africa: Lessons and Implications for Agricultural Research Institutions with an Annotated Bibliography*. CIMMYT Economics Program Paper 99-02. Mexico City: CIMMYT.

Elson, D. (1995). 'Gender awareness in modelling structural adjustment'. *World Development 23*, 1851–1868.

Food and Agriculture Organization (FAO) (2011). *Women in Agriculture: Closing the Gender Gap for Development*. State of Food and Agriculture report. Rome: FAO.

Feyertag, J., Malcolm, M., Langdown, I., Locke, A. and Nizalov, D. (2021). 'How does gender affect the perceived security of land and property rights? Evidence from 33 countries'. *Land Use Policy*, *104*. https://doi.org/10.1016/j.landusepol.2021.105299.

Fort, R. (2007). *Property Rights after Market Liberalization Reforms: Land Titling and Investment in Rural Peru*. Wageningen: Wageningen Academic Publishers.

Gebre, G.G., Isoda, H., Rajut, D.B., Amekawa, Y. and Nomura, H. (2021). 'Gender differences in agricultural productivity: evidence from maize farm households in southern Ethiopia'. *GeoJournal 86*, 843–864.

Goldstein, M. and Udry, C. (2008). 'The profits of power: land rights and agricultural investment in Ghana'. *Journal of Political Economy 116*, 981–1022.

Jamison, D.T. and Lau, C.J. (1982). *Farmer Education and Farm Efficiency*. Baltimore MD: Johns Hopkins University Press.

Kilic, T., Palacios-Lopez, A. and Goldstein, M. (2015). 'Caught in a productivity trap: a distributional perspective on gender differences in Malawian agriculture'. *World Development 70*, 416–463.

Krishna, V.V., Aravalath, L.M. and Vikraman, S. (2019). 'Does caste determine farmer access to quality information?' *PLoS One*, 25 January [available at https://doi.org/10.1371/journal.pone.0210721. accessed 30 September 2021]

Kulkarni, S., Bhat, S., Pallavi, H. and Satpute, S. (2021). 'Locked out of livelihoods: impact of covid-19 on single women farmers in Maharashtra, India'. *Economia Politica* (special issue). online. https:// doi. org/ 10. 1007/ s40888- 021- 00240-w

Kumar, S.M. (2013). 'Does access to formal agricultural credit depend on caste?' *World Development 43*, 315–328.

Ma, X. (2013). Does Tenure Security Matter? Rural Household Responses to Land Tenure Reforms in Northwest China, PhD thesis, Wageningen University, The Netherlands.

Mahajan, K. (2019). 'Back to the plough: women managers and farm productivity in India'. *World Development 124*. https://doi.org/10.1016/j.worlddev.2019.104633

Maravi, C. and Navarro, S. (2019). 'The role of land tenure security on agricultural investment: an empirical study in Peru'. Paper presented at the LACEA-LAMES conference, Puebla, Mexico.

Meinzen-Dick, R., Quisumbing, A., Behrman, J., Biermayr-Jenzano, P., Wilde, V., Noordeloos, M., Ragasa, C. and Beintema, N. (2011). *Engendering Agricultural Research, Development, and Extension*. Research Monograph. Washington DC: International Food Policy Research Institute.

Mishra, A.K., Khanal, A.R. and Mohanty, S. (2017). 'Gender differentials in farming efficiency and profits: the case of rice production in the Philippines'. *Land Use Policy 63*, 461–469.

Mullen, J.D. (2016). *Impact of Assessment of ICRISAT Village Level Studies: 1975–2013*. Patancheru, India: ICRISAT.

Nandi, T.K. (2010). 'Social networks and employment in India'. *Economics Bulletin 30*, 2769–2778.

Palacios-López, A. & López, R. (2015). The Gender Gap in Agricultural Productivity: The Role of Market Imperfections. *Journal of Development Studies 51*, 1175-1192.

Peterman, A., Quisumbing, A., Behrman, J. and Nkonya, E. (2011). 'Understanding the complexities surrounding gender differences in agricultural productivity in Nigeria and Uganda'. *Journal of Development Studies 47*, 1282–1509.

Quisumbing, A.R. (1996). 'Male–female differences in agricultural productivity: methodological issues and empirical evidence'. *World Development 24*, 1579–1595.

Quisumbing, A.R., Payongayongz, E., Aidoo, J.B. and Otsuka, K. (2001). 'Women's land rights in the transition to individualized ownership: implications for the management of tree resources in western Ghana'. *Economic Development and Cultural Change 50*, 157–182.

Rao, S. (2017). ‘Does caste discrimination affect agricultural performance in India?’. *Economic and Political Weekly 52*, 32–38.

Saito, K.A., Mekonnen, H. and Spurling, D. (1994). *Raising the Productivity of Women Farmers in Sub-Saharan Africa*. Discussion Paper, Africa Technical Department Series 230.Washington DC: World Bank.

Schweigert, T.E. (2006). ‘Land title, tenure security, investment and farm output: evidence from Guatemala’. *Journal of Developing Areas 40*, 115–126.

Sugden, F. (2010). ‘Agrarian change and pre-capitalist reproduction on the Nepal Terai’. PhD thesis. University of Edinburgh.

Sugden, F., Agarwal, B., Leder, S., Saikia, P., Raut, M., Kumar. A. and Ray, D. (2021). ‘Experiments in farmers’ collectives in eastern India and Nepal: process, benefits, and challenges’. *Journal of Agrarian Change 21*, 90–121.

Thapa, S. (2008). ‘Gender differentials in agricultural productivity: evidence from Nepalese households data’. Munich Personal ReREC Archive (MPRA) Paper 13722 [available at MPRA_paper_13722.pdf].

Udry, C., Hoddinott, J. Alderman, H. and Haddad, L. (1995). Gender Differentials in Farm Productivity: Implications for Household Efficiency and Agricultural Polic. *Food Policy* 20, 407–423.

Zhang, L., de Brauw, A. and Rozelle, S. (2004). ‘China’s rural labor market development and its gender implications’. *China Economic Review 15*, 230–247.

Appendix

Table A1: All landowner households, productivity regression: descriptive statistics (non-log values)

Variable name	N	Mean	CV	Min	Max
Dependent variable					
Total value of output/GCA (Rs/ha)	834	49003.15	1.182	247.1	658933.3[a]
Explanatory variables					
Gender of owner (female=1)	834	0.07	3.729	0	1
Gross cropped area (GCA in ha)	834	1.97	1.662	0.008	56.66
Total value of fertiliser/GCA (Rs/ha)	834	6340.17	1.032	0	61038.37
Total value of pesticide/GCA (Rs/ha)	834	885.83	2.277	0	24611.16
Tractor hours/GCA	834	12.75	8.482	0	2267.38
Total labour hours/GCA	834	432.97	1.045	2.995	4828.90
% male labour	834	53.50	0.438	0	100
% hired labour	834	37.18	0.716	0	100
% GCA irrigated	834	28.14	1.335	0	100
% GCA without soil problems	834	95.22	0.198	0	100
% GCA under food crops	834	74.10	0.491	0	100
Irrigation machine owned dummy (if owned =1)	834	0.51	0.977	0	1
Landowner makes no production decision dummy (no decision=1)	834	0.01	8.655	0	1
Literacy dummy: owner is literate=1	834	0.70	0.653	0	1
Caste dummy 1: owner is upper caste =1	834	0.23	1.817	0	1
Caste dummy 2: owner is OBC =1	834	0.36	1.308	0	1
Caste dummy 3: owner is SC or other =3 (reference category)	834	0.40	1.230	0	1
Regional dummy 1: south =1	834	0.20	1.978	0	1
Regional dummy 2: west+central =1	834	0.40	1.221	0	1
Regional dummy 3: east =1 (reference category)	834	0.39	1.240	0	1

Notes: N = number of cases. CV = coefficient of variation.

[a] This figure includes outliers with a very high annual value of output/ha on very small plots growing flowers such as chrysanthemums for commercial sale, and using high quantities of fertiliser and pesticides. This is also the case in Tables A2 and A3.

Table A2: Female landowner households, productivity regression: descriptive statistics (non-log values)

Variable name	N	Mean	CV	Min	Max
Dependent variable					
Total value of output/GCA (Rs/ha)	56	51963.46	1.631	694.97	561385
Explanatory variables					
Gross cropped area (GCA in ha)	56	1.97	2.425	0.06	34.80
Total value of fertiliser/GCA (Rs/ha)	56	8063.80	1.418	0	61038.37
Total value of pesticide/GCA (Rs/ha)	56	690.50	2.557	0	9884
Tractor hours/GCA	56	5.85	1.353	0	57.66
Total labour hours/GCA	56	584.96	1.475	22.24	4443.38
% male labour	56	46.51	0.577	4.08	100
% hired labour	56	37.66	0.782	0	100
% GCA irrigated	56	29.77	1.396	0	100
% GCA without soil problems	56	92.28	0.266	0	100
% GCA under food crops	56	77.88	0.455	0	100
Irrigation machine owned dummy (if owned=1)	56	0.29	1.595	0	1
Landowner makes no production decision dummy (no decision=1)	56	0.13	2.670	0	1
Literacy dummy: owner is literate=1	56	0.38	1.303	0	1
Caste dummy 1: owner is upper caste=1	56	0.18	2.164	0	1
Caste dummy 2: owner is from OBC=1	56	0.26	1.668	0	1
Caste dummy 3: owner is SC or others= 3 (reference category)	56	0.55	0.906	0	1
Regional dummy 1: south=1	56	0.20	2.040	0	1
Regional dummy 2: west+central=1	56	0.32	1.466	0	1
Regional dummy : east=1 (reference category)	56	0.48	1.046	0	1

Table A3: Male landowner households, productivity regression: descriptive statistics (non-log values)

Variable name	N	Mean	CV	Min	Max
Dependent variable					
Total value of output/GCA (Rs/ha)	778	48790.06	1.138	247.1	658933.3
Explanatory variables					
Gross cropped area (GCA in ha)	778	1.97	1.595	0.008	56.66
Total value of fertiliser/GCA (Rs/ha)	778	6216.10	0.970	0	55494.54
Total value of pesticide/GCA (Rs/ha)	778	899.89	2.261	0	24611.16
Tractor hours/GCA	778	13.24	8.450	0	2267.38
Total labour hours/GCA	778	422.03	0.962	2.995	4828.89
% male labour	778	54.002	0.427	0	100
% hired labour	778	37.14	0.711	0	100
% GCA irrigated	778	28.03	1.331	0	100
% GCA without soil problems	778	95.43	0.192	0	100
% GCA under food crops	778	73.82	0.494	0	100
Irrigation machine owned dummy (if owned=1)	778	0.53	0.946	0	1
Literacy dummy: owner is literate=1	778	0.72	0.616	0	1
Caste dummy 1: owner is upper caste =1	778	0.24	1.798	0	1
Caste dummy 2: owner is OBC =1	778	0.38	1.287	0	1
Caste dummy 3: owner is SC or others=1 (ref cat)	778	0.39	1.260	0	1
Regional dummy 1: south=1	778	0.20	1.974	0	1
Regional dummy 2: west+central=1	778	0.40	1.206	0	1
Regional dummy 3: east=1 (ref cat)	778	0.39	1.256	0	1

Note: ref cat = reference category.

Table A4: Self-cultivator regressions: descriptive statistics

	N	Mean	CV	Min	Max
	All landowner households				
Dummy: self-cultivator households=1	927	0.90	0.334	0	1
Gender of landowner (female=1)	927	0.09	3.234	0	1
Total area owned (ha)	927	1.69	1.318	0.01	26.71
% owned area that is irrigable	927	51.66	0.832	0	100
Literacy dummy: owner is literate=1	927	0.49	1.012	0	1
Irrigation machine owned dummy (if owned=1)	927	0.70	0.651	0	1
Age of owner (years)	927	52.15	0.243	18	94
Number of household members $\geq$ 15 years	927	4.06	0.447	1	15
Caste dummy 1: owner is upper caste=1	927	0.24	1.762	0	1
Caste dummy 2: owner is OBC=1	927	0.35	1.355	0	1
Caste dummy 3: owner is SC or other=1 (ref cat)	927	0.40	1.217	0	1
Regional dummy 1: south=1	927	0.23	1.843	0	1
Regional dummy 2: west+central and east=1 (ref cat)	927	0.77	0.543	0	1
	Female landowner households				
Dummy: self-cultivator households=1	81	0.69	0.672	0	1
Area owned (ha)	81	1.53	1.964	0.10	20.23
% owed area that is irrigable	81	45.71	1.01	0	100
Irrigation machine owned dummy (if owned=1)	81	0.31	1.506	0	1
Literacy dummy: owner is literate=1	81	0.37	1.311	0	1
Age of owner (years)	81	52.40	0.210	18	76
Number of household members $\geq$ 15 years	81	3.46	0.539	1	14
Caste dummy 1: owner is upper caste =1	81	0.20	2.028	0	1
Caste dummy 2: owner is OBC =1	81	0.23	1.818	0	1
Caste dummy 3: owner is SC or other=1 (ref cat)	81	0.57	0.878	0	1
Regional dummy 1: south=1	81	0.35	1.384	0	1
Regional dummy 2: west+central and east=1 (ref cat)	81	0.65	0.731	0	1
	Male landowner households				
Dummy: self-cultivator households=1	846	0.92	0.296	0	1
Area owned (ha)	846	1.71	1.255	0.01	26.71
% owned area that is irrigable	846	52.23	0.82	0	100
Irrigation machine owned dummy (if owned=1)	846	0.51	0.977	0	1
Literacy dummy: owner is literate=1	846	0.73	0.602	0	1
Age of owner (years)	846	52.13	0.247	22	94
Number of household members $\geq$ 15 years	846	4.12	0.437	1	15
Caste dummy 1: upper caste owner=1	846	0.25	1.741	0	1
Caste dummy 2: OBC owner=1	846	0.36	1.322	0	1
Caste dummy 3: SC or other owner=1 (ref cat)	846	0.39	1.257	0	1
Regional dummy 1: south=1	846	0.22	1.904	0	1
Regional dummy 2: west+central and east=1 (ref cat)	846	0.78	0.526	0	1