The value of wild pollination ecosystem services to crop production: What does gender of the smallholder farmer got to do with it?

"Men's crops" and "women's crops" suggest that men and women smallholder farmers in sub-Saharan Africa grow different crops[1-10]. This gendered-crops, as documented by a series of studies, is tied to whether production is for generating household food or crops for market sales. "Food crops", "subsistence crops" and "cash crops" are similarly familiar, where "cash crops" are mainly produced by men and "food crops" and "subsistence crops" by women[1, 4, 6, 8, 11-16]. Yet, this gender division of crops is not considered in the valuation of wild pollinators to crop productivity, and therefore remains unknown, despite considerable coverage of wild pollination ecosystem services[17-19]. Our hypothesis is that the presence of gendered-crops is likely to lead to different crop pollination needs and hence variation in benefits between male- and female-managed smallholder farms. We test this by linking a nationally representative panel survey of over 10,000 actual smallholder plots managed by male and female farmers; with spatially and temporally land cover maps; together with robust fixed-effects production function methods. We find evidence of gendered-crops and variation in the pollination dependency in male- and female-managed farms. Furthermore, the statistically significant fixed-effects estimates produce an exponential function which shows that proximity to wild pollinators' natural habits - forests - is important, and that at shorter distances female-managed farms benefit four times more than male-managed farms, and this tapers off as distance increases producing convergence in benefits. We are able to conclude that conservation that preserves the natural habitants of wild pollinators will enhance crop yield especially among female-managed farms. This demonstrates the importance of gender in ecosystem services and suggests that to fully understand their benefits, gender needs to be incorporated into natural capital and sustainable development policies governing smallholder agriculture rich regions.

Sub-Saharan Africa's agriculture has consistently been traditionally gendered[1,5-6,11-12,20-28]. About crops, earlier studies indicate the presence of gendered-crops[12-13, 29-32], and this continues to be documented by recent studies[3, 4,6,8,15-16]. For many years, the value of pollinators to crop productivity has been a subject of interest globally[33-37], with the values feeding into natural capital and sustainable development policies. However, it is important to further our understanding by exploring sub-Saharan Africa's smallholder farms together with the gendered-crops that go along with it. This is important because different crops have different pollinator dependency suggesting that pollination needs of crops grown by male and female smallholder farmers could somewhat be different, and so could the benefits. That is, according to Food and Agriculture Organisation of the United Nations[17, 38] this includes crops that belong in the *essential category,* where crop yield decreases by more than 90% in the absence of animal pollinators. The next category is *great, and this is where* crop yield reduces by 40-90%; thereafter, *modest,* is a category where production is reduced by 10-40%; (iv) *little* - production decreases by 0-10%, (v) Shows an increase in seed production or breeding or yield in response to animal pollination, (vi) doesn't show an increase in yield in response to animal pollination, e.g., maize (vii) *unknown* - this is a classification with no literature available.

For these reasons, our study addresses the following questions: Are the crops grown by male different from those of female farmers? Is there a difference in pollinator dependency between men's crops and women's crops? Is there a difference in the economic value of wild pollination between male- and female-managed smallholder farms? To answer these questions, we use the three-year Tanzania National Panel Survey (NPS) which contains smallholder plot-level information across the country (see Figure 1). The advantage of NPS is that the plot-level information consists of on an assortment of seasonal and annual crops of male and female farmers grown in a single year. To capture the gender differences, we use gender of the head of the household as they make household decisions such as managing smallholder farms. We use the production function methods where our outcome is crop revenue per hectare. The production input - wild pollination ecosystem services is captured by pollinators' natural habitants - forests - and this is proxied by using land cover maps and constructing six forest share buffers with varying radius (100m, 250m, 500m, 1000m, 2000m and

3000m) from the edge of the plot, following scientific evidence pollinator habitants and foraging[39-43]. This captures the flight distances of pollinators. Here we use Hansen et al. (2013) land cover maps together with plot location to match the share of forests around each plot (See Figure 2). The production models are run separately for male- and female-managed farms. Smallholder farmers grow an array of crops each with different pollination needs. To aid in identification, we use FAO's agro-ecological assessments and estimate with different outcomes: plot-level crop revenue per hectare from (i) pollinator-dependent crops, (ii) pollinator-independent crops and (iii) all crops (See methods). A series of household, farm and climate characteristics are added in the function as controls.

Our results support our hypothesis by showing the following: First, upon comparing the long-rains, short-rains, and annual crops, we find evidence of gendered-crops in support of the current literature. That is, in each season, men are more inclined to produce and earn more from cash crops, women on the other hand are more likely to earn more revenue from fruits (See the test of mean statistics in Extended Data Tables 1 and the list of crops produced by male and female farmers in Extended Data Table 2). Added to this, men farmers are more active during the rainy season, women on the other hand are present throughout the year including the non-rainy seasons This further confirmed by maximum-likelihood multinomial logit models which shows the female coefficient is statistically significant indicating that the gender of the smallholder farmers determines crop selection (See Extended Data Tables 3). Taken together, this suggest that women and men farmers select crops by (i) farming seasons (short- or long-rains crops), and (ii) type of crops (fruits, vegetables, pulses/legumes, grains/cereals, roots/tubers, nuts, seeds and traditional/cash crops). However, it is unlikely that farmers select crops by their pollination needs, but because the farming season and type of crops are highly correlated with pollination needs, in essence these farmers are unknowingly making crop - pollination selection.

Second, the fixed-effects production estimates show that the natural habitant coefficients are more responsive amongst female-managed farms in comparison to male-managed farms. When contrasting pollinator-dependent and pollinator-independent crops, we find the positive effects of natural habitant emerge only for pollination dependent crops. Non-pollination dependent crops show no benefits. More specifically, the production function fixed-effects model shows how forests - the natural habitants of wild pollinators - contribute to crop revenue (Table 1). The full models are in Extended Data Tables 4, 5 and 6. In Table 1, panels A, B, C report the estimated coefficients when the outcome is pollinator-dependent crop revenue per hectare, revenue per hectare from all crops and pollinator-independent crops respectively. We generally observe significant coefficients, when positive, suggesting an increment in crop revenue with increase in the share of pollinators' natural habitats. Added to this, in Panel A, we observe that female-managed farms' crop revenue is more responsive to the natural habitants of pollinators up-to 200m radius. When we consider revenue from all crops (Panel B), we again observe more responsiveness from female-managed farms. However, when we narrow down to pollinator-independent crops, our robustness check, and use the pollinator-independent crop revenue as the outcome (Panel C), we observe dismal responsiveness in both male- and female-managed farms. The expected result from the robustness test somewhat rules out any explanation from the influence of unobservables.

Third, Figures 3-5 illustrate the marginal value using the production estimates presented in Table 1. The estimates from the six buffers of pollinator-dependent crops (from Panel A in Table 1) produce an exponential function which shows the marginal values of the natural habitant declining with increment in distance between the farm plot and forests. Although an exponential function is evident for pollinator-dependent crops (Figure 3) and all crops (Figure 4), this does not appear under the pollinator-independent crops (Figure 5) which somewhat captures the lack of contribution between natural habitants of wild pollinators and pollinator-independent crops. At the same time, when we compare between female- and male-managed farms, the exponential function shows that at shorter distances female-managed farms benefit the most from wild pollination services in comparison to male-managed farms, and this tapers off as distance increases and we finally observe a convergence in benefits. Suggesting that the positive effect from proximity of forests is associated with ability of forests to support pollinator populations and boost crop production.

To conclude, gender, has overtime been proven to be an important dimension in the livelihoods of sub-Saharan Africans' households. Generally, women and their households in sub-Saharan Africa depend more on smallholder agriculture for their livelihood[44-46]. In strengthen the current evidence, our study shows the importance of gender and suggest an inclusion in natural capital and sustainable development policies.

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	Panel 1: Male managed farms						Panel 2: Female managed farms					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Panel A: Outcome - pollinator-dependent crops revenue per hectare												
Share of wild pollinator natural habitats at 100m radius	20,999**						63,644**					
	(7,838)						(20,677)					
Share of wild pollinator natural habitats at 250m radius		30,948**						23,384***				
		(12,660)						(5,082)				
Share of wild pollinator natural habitats at 500m radius			48,984**						7,580			
			(20,395)						(21,563)			
Share of wild pollinator natural habitats at 1000m radius				41,019**						17,426		
				(16,695)						(16,183)		
Share of wild pollinator natural habitats at 2000m radius					66,392***						15,024	
					(18,353)						(24,278)	
Share of wild pollinator natural habitats at 3000m radius						82,201***						-67,555
						(22,560)						(67,624)
Panel B:Outcome - all crops revenue per hectare												
Share of wild pollinator natural habitats at 100m radius	18,592*						92,355**					
	(9,433)						(36,134)					
Share of wild pollinator natural habitats at 250m radius		30,544*						72,212**				
		(15,954)						(29,196)				
Share of wild pollinator natural habitats at 500m radius			51,719*						55,131***			
			(26,533)						(15,382)			
Share of wild pollinator natural habitats at 1000m radius				50,996**						48,674***		
				(21,277)						(6,210)		
Share of wild pollinator natural habitats at 2000m radius					78,705**						69,462***	
					(25,664)						(11,951)	
Share of wild pollinator natural habitats at 3000m radius						94,855**						59,017***
						(33,398)						(6,343)
Panel C:Outcome - pollinator-independent crops revenue per hectare												
Share of wild pollinator natural habitats at 100m radius	1,290*						588.7					
	(664.7)						(795.7)					
Share of wild pollinator natural habitats at 250m radius		2,734*						-557.5				
		(1,383)						(768.3)				
Share of wild pollinator natural habitats at 500m radius			4,589						-1,428			
			(2,624)						(1,821)			
Share of wild pollinator natural habitats at 1000m radius				6,721**						-472.1		
				(2,369)						(2,553)		
Share of wild pollinator natural habitats at 2000m radius					7,045***						-320.9	
					(2,152)						(3,671)	
Share of wild pollinator natural habitats at 3000m radius						7,197**						2,803
						(2,677)						(3,847)
Observations	8,931	8,931	8,931	8,931	8,931	8,931	2,512	2,512	2,512	2,512	2,512	2,512

Table 1: Estimation results from fixed-effects models to predict crop revenue from pollinator-dependent, pollinator-independent and crops all crops. The estimation results come from panel regression models estimated separately for each radius (100m, 250m, 500m, 1000m, 2000m, 3000m). The estimation models control for plot characteristics (soil quality; slope; distance to farm road, and market), production inputs (expenses in labor, fertilizer, seed), farmer characteristics (age, education, agricultural extension services, female versus male headed households, off-farm employment), and weather (temperature and rain). The full regression models are available in Extended Data Table 4, 5 and 6**.**

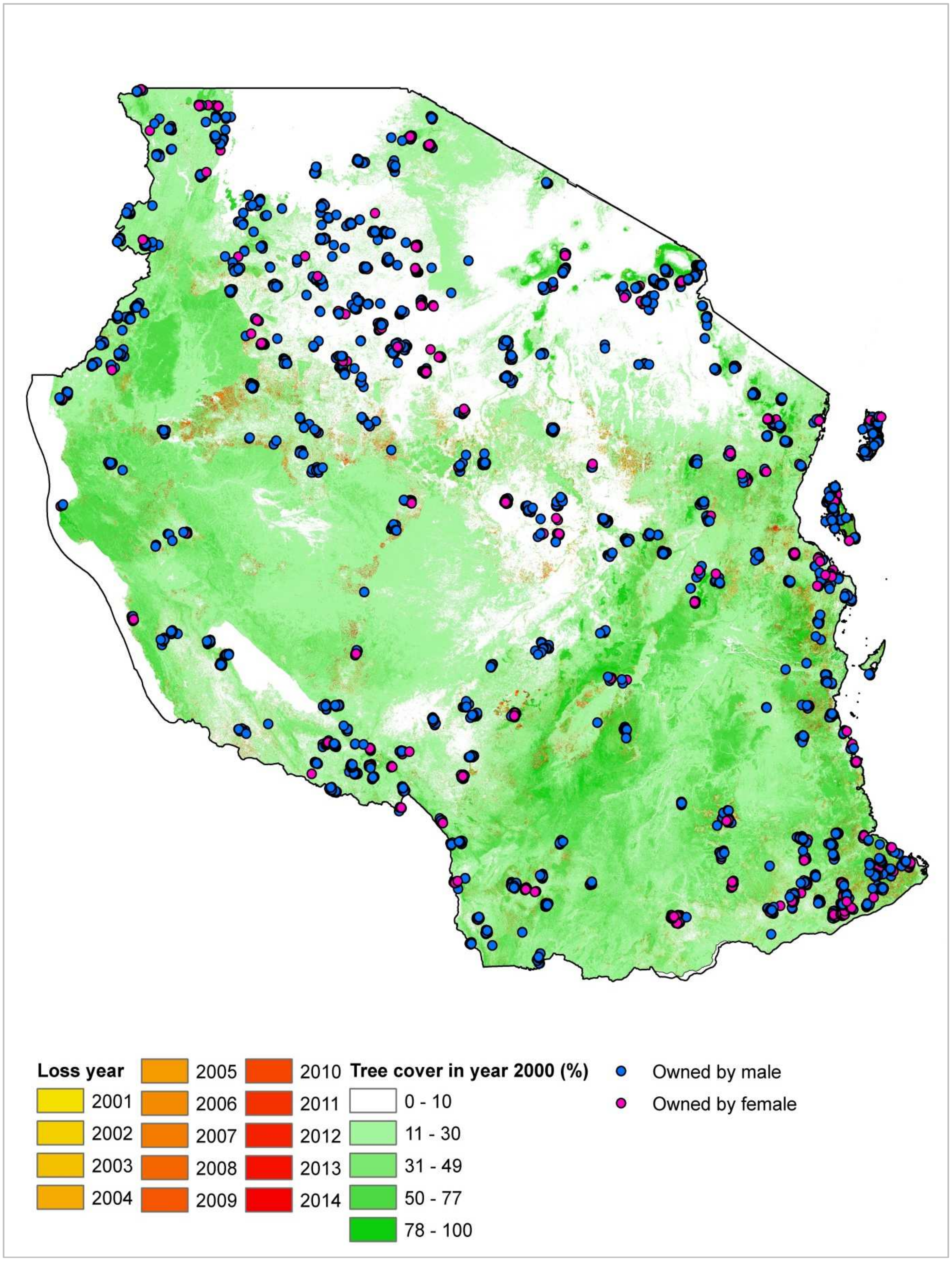

Figure 1: Distribution of farm plots by gender. The blue dots indicate male-managed plots while the pink are those plots managed by women from Hansen maps. There are relatively more plots earned by men than woman and the male managed plots are mainly surrounded by forests and grasslands.

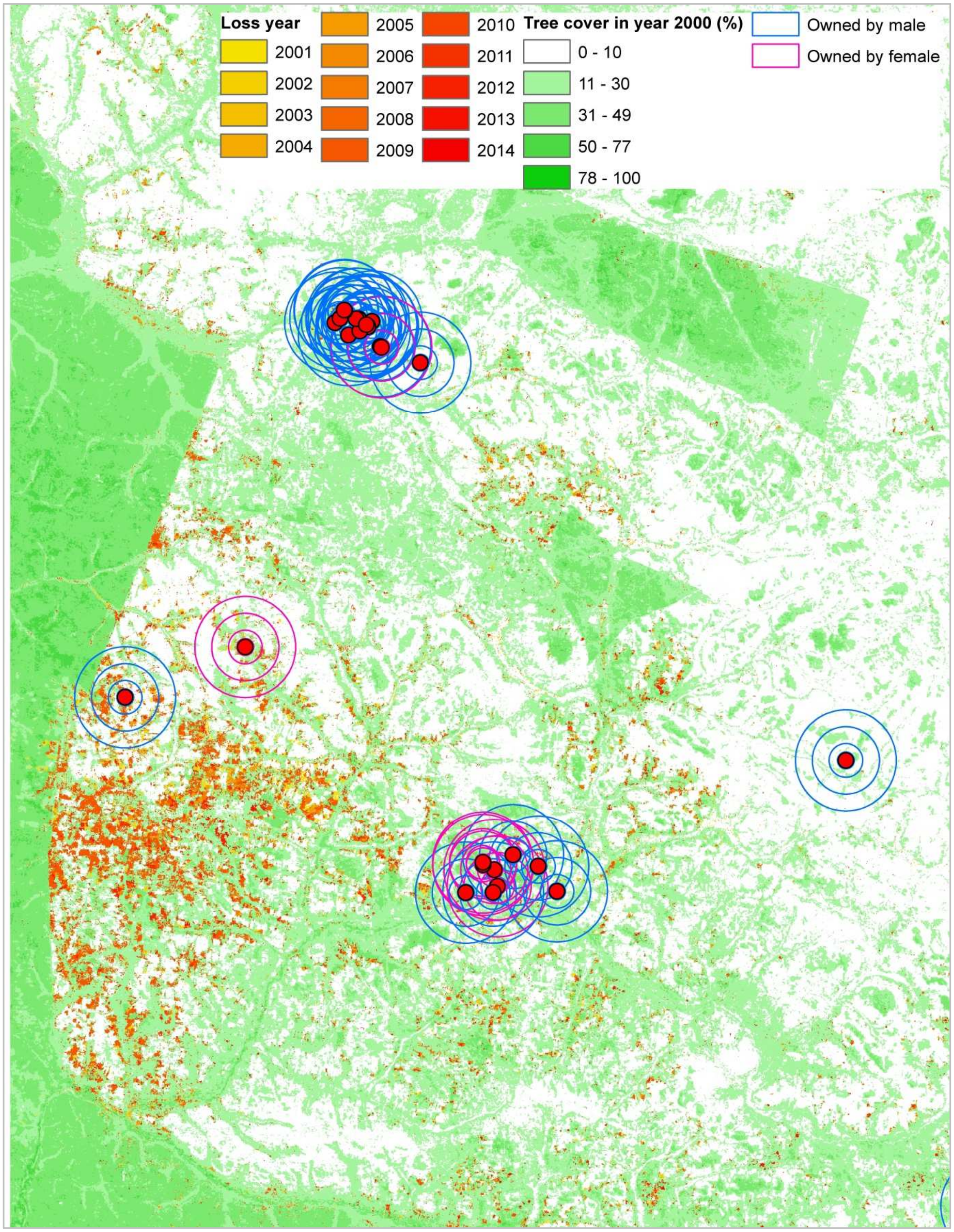

Figure 2: Wild pollinator proxy - forests - their natural habitat. We use the land cover to develop the wild pollinator proxy which is the captured by forests, the natural habitats, buffers of different radius from Hansen maps. That is, buffers with 100m, 250m, 500m, 1000m and 3000m radius were constructed around each plot, from the edge. Using GIS plot information and land cover maps, the type of land cover within each buffer was identified. Thereafter, the percentage share of forest within each buffer is calculated. We assumed a circular shape of each plot.

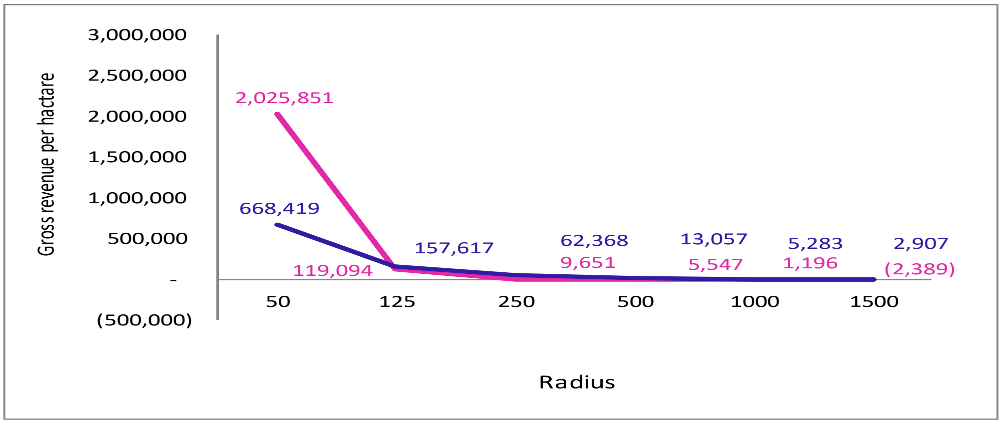

Figure 3: Per hectare contribution of natural habitants - forests - to crop revenue (per hectare), by distance from the agricultural plot. __Pollinator-dependent crops__. Regression estimates from Panel A in Table 1 are used to derive the value of forest to total crop revenue per hectare. The marginal value of forests, per hectare, is declining with distance between forest and agricultural plot. The values are in Tanzania Shillings (TSH), where US$1 ≈ TSH2000

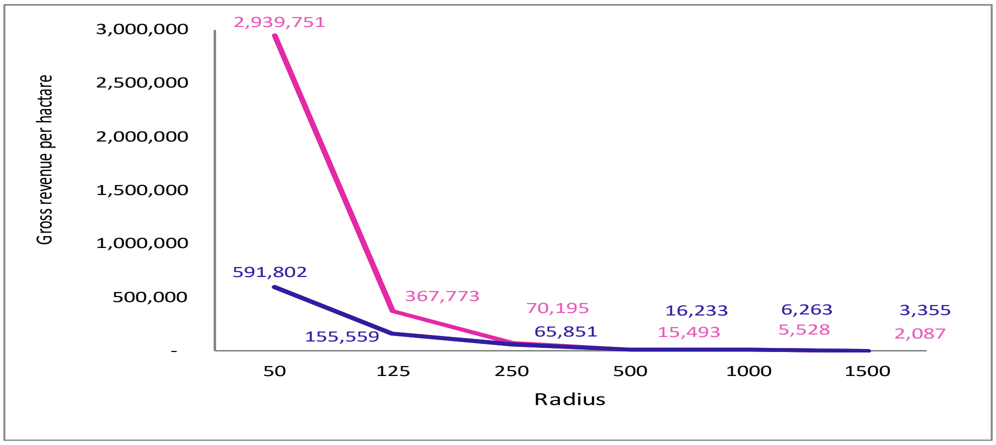

Figure 4: Per hectare contribution of forests to crop revenue (per hectare), by distance from the agricultural plot. __All crops__. Regression estimates from Panel B in Table 1 are used to derive the value of forest to total crop revenue per hectare. The marginal value of forests, per hectare, is declining with distance between forest and agricultural plot. The values are in Tanzania Shillings (TSH), where US$1 ≈ TSH2000

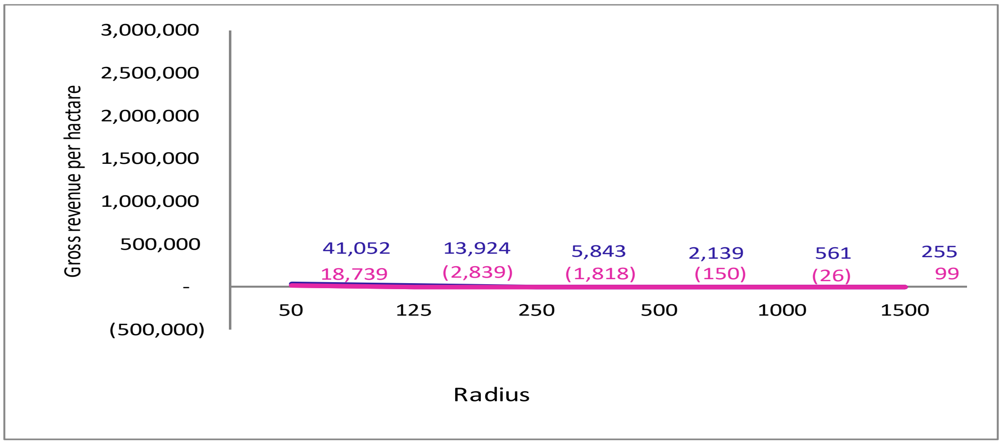

Figure 5: Per hectare contribution of forests to crop revenue (per hectare), by distance from the agricultural plot. __Pollinator-independent crops__. Regression estimates from Panel C in Table 1 are used to derive the value of forest to total crop revenue per hectare. The marginal value of forests, per hectare, is declining with distance between forest and agricultural plot. The values are in Tanzania Shillings (TSH), where US$1 ≈ TSH2000

METHODS

The data and model. For smallholder farm information, we use the Tanzania National Panel Survey (NPS). This is a nationally representative household survey with 3 waves: 2008, 2010 and 2013. The survey is managed by Tanzania national bureau of statistics with support from the Word Bank. To formally measure the effects of pollination services to smallholder crop productivity, we use the production function model, where we estimate a fixed-effects model for male- and female-managed farms separately. This is presented in equation (1) following Freeman (1993) where y is crop revenue per hectare, $\mathbf{x}$ is a vector of controls which includes farm inputs, and plot, household, soil and climate characteristics. Finally, q, is the pollination service, added as an additional input in the production function, μ_i and ε_{it} are the random disturbances and the subscripts *i* and *t* represents the *i*-th plot in the *t*-th time period as the primary unit is output from each plot.

$$y_{it} = \beta_0 + \beta_1 q_{it} + \mathbf{x\beta} + \mu_i + \varepsilon_{it} \qquad (1)$$

By taking advantage of the panel nature of the data and using fixed-effects we are able to absorb time-invariant unobservables. However, for time-varying unobservables we perform various tests to determine its influence, if any. In measuring the gender differences, we use the gender of the head of the household on the premise that they are likely to make decision on behave of households. This approach is available in the current literature[2,6,47,48] and evident in Tanzania. That is, the NPS asked households to mention the person who decides the crops to be planted, more specifically: “Who decided what to plant on this plot in the (long rainy/short rainy/permanent) season…?”. About 93.9% indicated that it was the head of the household.

As previously mentioned the outcome, y, is crop revenue per hectare. For robustness – to test any influence from unobservables – we take advantage of the different crops grown by smallholder farms in Tanzania in a single plot. These include long-rains crops, which are planted during the long-rains (February/March - June/July); short-rains crops that target the short-rains season (September/October - January/February), and there are crops that are planted throughout the year. Combined together these crops consists of grains (e.g., maize, rice), tubers (e.g., cassava, potatoes), fruits (e.g., watermelons, oranges), vegetables (e.g., tomatoes, onions), nuts (e.g., cashew nuts, peanuts) and seeds (e.g., sunflower). According to the Food and Agriculture Organisation of the United Nations[17, 38], crops have different pollinator needs and they have accordingly categorised crops into the following: *Essential:* crop production reduces by more than 90% in absence of animal pollinators (e.g., papaw, passions). *Great:* where crop yield reduces by 40-90% (e.g., mango, avocado); *Modest:* production is reduced by 10-40%. (e.g., sunflower, coffee); *Little:* production decreases by 0-10% (e.g., beans, groundnut); *Shows an increase in seed/ breeding/yield* in response to pollination (e.g., cassava, cocoyams); *Doesn't show an increase* in yield in response to animal pollination (e.g., maize, paddy); *Unknown***:** No literature (e.g., monkey-bread, sisal grown by farmers in Tanzania).

Hence the robustness test uses different outcomes owing to the richness of our data. The first is pollinator-dependent crop revenue per hectare. This aggregates revenue earned from ‘essential’, ‘great’, ‘modest’, ‘little’ and ‘increase’. The second outcome is revenue per hectare earned from all crops. The third outcome is pollinator-independent crop revenue per hectare, which consist of revenue from crops that fall under ‘Doesn't show an increase’. Our proxy follows from the sciences which outline (i) that forests are likely to be the natural habitants of wild pollinators[39,42,49] and (ii) on pollinators' foraging distance[41,43]. From this, we use the Hansen et al. (2013) land cover maps and plot location to determine the share of forests around each plot. This consists of 30m by 30m resolution annual forest cover in the years 2000-2014. Figure 1 shows the distribution of male- and female-managed farm plots across the country. From the land cover maps, we develop the wild pollinator proxy which is share of forests, the natural habitats of wild pollinators, in buffers of different radius. There are six buffers consisting of concentric circles with 100m, 250m, 500m, 1000m, 2000m and 3000m radius from the edge of the plot. Figure 2 shows the buffers around each plot, here we assume that the plots are circularly shaped.

Data description. Extended Data Tables 7 shows the summary statistics. The household characteristics reveal that the male heads of households are younger, slightly more educated, have more livestock, are likely to be married and have an off-farm employment. The plot-level characteristics show that male-managed farms generate higher revenue per hectare in comparison to female-managed farms. They also have slightly larger farm size and spend more inputs (labour, fertilisers and seedlings) than women. This is consistent with past studies which indicate that farms managed by men are likely to have more resources[5,8,23,50]. Female-managed farms are however closer to homes, roads and markets. As expected, the majority of the smallholder farmers, both men and women, grow crops in the long-rains, in comparison to short-rains season or permanent crops (fruits and permanent crops).

This is likely driven by the dependency of rain-fed smallholder agriculture. Surprisingly, according to the descriptive statistics, we see that male-managed farms are surrounded with more forest cover in comparison to female-managed farms. The forest statistics, in Extended Data Tables 7, are augmented with Extended Figure 1 which shows the forest share around the plots of male- and female-managed farms in 2008-2013. Here we observe a consistently larger share of forests around male-managed farms in comparison to female-managed farms in all the different buffers. Another interesting observation is that while the forest share around the female-managed farms decreases with distance, the share of forest cover around the male-managed farms is increasing with distance. For robustness check we compare with an alternative land cover - SERVIR land cover maps. Unlike the Hansen et al. (2013) land cover maps which only shows forest and non-forest categories, the SERVIR land cover uses 5 categories: forest, grassland, wetland, cropland, settlement and other lands. The pattern observed under Hansen et al. (2013) is similarly observed in the SERVIR land cover maps (see Extended Figure 2). Further to this, plots managed by women have higher share of settlements and grasslands around them, while those managed by men are surrounded by a higher share of forests and crop lands around the farm plots (see Extended Figure 3). This may perhaps explain the assertion in the current literature that women are more likely to cultivate on land near the households, while men's fields are likely to be large fertile farm lands[23,30,45,46,51]. This is further supported by our statistics which show that female farms are closer to the household than male farms, and where the male farms are larger with higher soil quality than women farms (Extended Data Tables 7).

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EXTENDED DATA

		Male farmers		Female farmers		Mean difference		male	female	% difference
		Mean	Median	Mean	Median					
long-rains crops	fruit crops	131397	70110	247167	37500	-115770	(124796)	1.2	23.7	-22.5
	veg	9892140	61800	110476	66000	9781664	(15000000)	87.1	10.6	76.6
	pulses	139528	29070	74381	28196	65146	(24062)	1.2	7.1	-5.9
	grains/cereal	172930	79625	134563	70667	38367	(10830)	1.5	12.9	-11.4
	tubers	123005	39762	77045	34000	45959	(35896)	1.1	7.4	-6.3
	nuts	81476	41744	76137	38480	5339	(12829)	0.7	7.3	-6.6
	seed	105558	32056	46213	22975	59345	(70411)	0.9	4.4	-3.5
	cash/traditional crops	236044	113734	130289	62129	105755	(60935)	2.1	12.5	-10.4
	others	469500	88417	147624	57697	321876	(351947)	4.1	14.1	-10.0
short-rains crops	fruits	27838	28875	69633.3	64000	-41795	(41890)	1.8	2.4	-0.6
	veg	735204	110000	397523	195000	337681	(1174499)	47.6	13.5	34.1
	pulses	87330	25529	48590	31582.6	38740	(40378)	5.7	1.6	4.0
	grains/cereal	98402	38421	100109	40342.3	-1707	(16554)	6.4	3.4	3.0
	tubers	105423	37887	82249.9	53415	23173	(35679)	6.8	2.8	4.0
	nuts	97268	36000	143309	49348.2	-46041	(56790)	6.3	4.9	1.4
	seed	120750	124200	1869000	1869000	-1748250	(1062654)	7.8	63.3	-55.5
	cash/traditional crops	130790	81227	202406	213820	-71616	(64695)	8.5	6.9	1.6
	others	141496	23179	40870.4	40870.4	100625	(315351)	9.2	1.4	7.8
fruit crops	fruits	78663	8781	93942	9656	-15279	(17078)	75.5	54.6	20.9
	nuts	-	-	50000	50000	-		-	29.0	-29.0
	cash/traditional crops	9736	2111	11500	11500	-1764	(16447)	9.3	6.7	2.7
	others	15797	3518	16711	5223	-914	(9107)	15.2	9.7	5.5
permanent crops	fruits	110530	13876	484138	7688	-373608**	(160179)	9.1	33.8	-24.7
	veg	640	640	4500	4500	-3860		0.1	0.3	-0.3
	pulses	164556	22848	88238	11748	76318	(112891)	13.6	6.2	7.5
	tubers	116357	16735	342924	24663	-226567***	(80726)	9.6	24.0	-14.3
	nuts	110581	25225	93108	19929	17473	(56097)	9.2	6.5	2.6
	seed	70830	20000	133267	33445	-62436**	(31097)	5.9	9.3	-3.5
	cash/traditional crops	523110	28158	282761	17605	240349	(427469)	43.3	19.8	23.5
	others	111815	0	1893	0	109922	(86788)	9.3	0.1	9.1

Extended Data Table 1: Differences in crop revenue across farming season and gender. Here we compare the crop revenue per hectare earned in the different farming seasons by gender. In each season we group the crops into fruits, vegetables, pulses/legumes, grains/cereals, roots/tubers, nuts, seeds and traditional/cash crops following the national agriculture census of Tanzania. During the long-rains, the majority of the crop revenue for male farmers is earned from cash crops vegetables, and grains. There is also substantial revenue earned from other crops, however it is unclear what ‘this category includes. Among women farmers, the majority of the crop revenue is from fruit crops, followed by grains and cash crops, also there is a large amount earned from other crops. Here the test of mean statistics produces insignificant results. During the short rains, men continue to earn more revenue from vegetables, cash crops, and other crops, similarly, women’s revenue is mainly from seeds, vegetables, and cash crops. The test of mean statistics continues to produce insignificant results. Under crop revenue from fruits, women farms earn more revenue in comparison to men. However this difference is not statistically significance as shown by the test of mean difference. The permanent crops earn more revenue for women farmers compared to male farmers. This difference is statistically significant as shown by the test of mean difference. Further this mean significance is higher among fruits. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

		LONG-RAINS	SHORT-RAINS	permanently-FRU	permanently-PER
FRUITS	Male	Coconut, Banana Mango, Orange Watermelon Bilimbi	Coconut Banana Watermelon	Malay apple, Star fruit Bread fruit, Jack fruit Passion Fruit, Banana Avocado, Mango, Plum Papaw, Pineapple Orange, Grapefruit Grapes, Mandarin Guava, Plums, Apple Apples, Pears, Mitobo, Peaches, Watermelon Rambutan, Custard Peaches, Pomegranate Date, Lime, Lemon	Coconut, Banana Pineapple Grapes Monkeybread
	Female	Banana, Plums	Banana Bilimbi Rambutan	Star fruit, Bread fruit, Jack fruit, Passion Fruit, Pears, Peaches Banana, Avocado, Papaw, Pineapple, Mandarin, Guava, Orange, Apples, Mango Bilimbi, Custard Apple God Fruit, Plum Peaches, pomegranate Date, Lime, Lemon	Coconut Pineapple Monkeybread
VEGS	Male	Onions, Cabbage Tomatoes, Spinach Carrot, Chillies Amaranths, Pumpkins, Watermelon, Okra, Cucumber, Fiwi	Onions, Cabbage Tomatoes, Spinach Carrot, Chillies Amaranths Pumpkins, Cucumber Egg Plant, Watermelon Cauliflower, Okra	Watermelon	Green Tomato
	Female	Onions, Cabbage Tomatoes, Amaranths, Cauliflower, Okra, Fiwi, Pumpkins, Cucumber	Cabbage, Tomatoes Amaranths, Pumpkins, Fiwi	Watermelon	Green Tomato
LEGUME /PULSES	Male	Beans, Cowpeas Green gram, Pigeon pea, Field peas, Soya beans	Beans, Cowpeas Green gram, Pigeon pea, Chick peas Field peas, Soya beans		Pigeon pea
	Female	Beans, Cowpeas, Chick peas Green gram, Field peas Pigeon pea, Chick peas,	Beans, Cowpeas Green gram, Pigeon pea, Field peas,		Pigeon pea
GRAINS	Male	Maize, Paddy, Sorghum, Bulrush Millet, Finger Millet, Wheat	Maize, Paddy, Sorghum Bulrush Millet, Finger Millet		
	Female	Maize, Paddy Sorghum, Wheat Bulrush Millet	Maize, Paddy Sorghum Wheat		

		Finger Millet			
TUBERS	Male	Cassava, Yams Sweet Potatoes Irish potatoes Cocoyams	Cassava, Yams Sweet Potatoes Irish potatoes Cocoyams		Cassava Cocoyams
	Female	Cassava, Yams Sweet Potatoes Irish potatoes, Cocoyams	Cassava, Yams Sweet Potatoes Cocoyams		Cassava Cocoyams
NUTS	Male	Bambara nuts Groundnut, Cashewnut	Bambara nuts Groundnut		Cashew nut
	Female	Bambara nuts Groundnut	Bambara nuts Groundnut	Groundnut	Cashew nut
SEEDOIL	Male	Sunflower Simsim	Sunflower Simsim, Palm Oil		Palm Oil
	Female	Sunflower Simsim	Sunflower		Palm Oil
TRADITION	Male	Seaweed, Cotton, Tobacco, Sisal, Coffee, Cocoa	Cotton, Tobacco	Durian, Vanilla	Black Pepper, Sisal, Coffee, Tea, Cocoa, Cardamom, Tamarin, Cinamon, Bamboo Nutmeg, Clove,
	Female	Cotton Tobacco Sisal	Cotton Tobacco	Durian	Black Pepper, Sisal, Cocoa, Wattle, Kapok, Coffee, Cardamom, Tamarin, Cinamon Tea, Clove, Bamboo Sugar Cane,

Extended Table 2: 'Men's crops and women's crops' among small-holder farmers in Tanzania. Here we provide more details by listing the crops grown by male and female farmers in each of the planting seasons. That is, we show the crops that may be found among male and female farmers in the different seasons.

Outcome: Type of crops	(1) fruits	(2) vegetables	(3) legumes/pulses	(4) grains/cereals	(5) tubers	(6) nuts	(7) seeds	(8) traditional/cash
				RAINY SEASONS CROPS				
				Long-rains seasons				
female farmers	**0.803****	**-0.416**	**0.126**	**0.0452**	**-0.544*****	**-0.166**	**0.0888**	**-0.666**
	(0.396)	(0.292)	(0.104)	(0.0383)	(0.0893)	(0.166)	(0.824)	(0.560)
				Short-rains seasons				
female farmers	**0.803****	**-0.416**	**0.126**	**0.0452**	**-0.544*****	**-0.166**	**0.0888**	**-0.666**
	(0.396)	(0.292)	(0.104)	(0.0383)	(0.0893)	(0.166)	(0.824)	(0.560)
				ANNUAL CROPS				
				Fruit crops				
female farmers	**-0.135*****	**85.62*****	**-0.0271**	**-**	**-0.0502**	**0.0763**	**-0.0507**	**-0.225*****
	(0.0406)	(5.256)	(0.0956)	-	(0.0442)	(0.0808)	(0.333)	(0.0574)
				Permanent crops				
female farmers	**-0.226*****	**-**	**-**	**-**	**-**	**28.39*****	**-**	**-1.276*****
	(0.0831)	-	-	-	-	(1.227)	-	(0.199)

Extended Data Table 3: Maximum-likelihood multinomial logit models to show how gender determines crop selections in each season. The maximum-likelihood multinomial logit models show the determinants of crop selections, The estimation models control for plot characteristics (soil quality; slope; distance to farm road, and market), production inputs (expenses in labor, fertilizer, seed), farmer characteristics (age, education, agricultural extension services, female versus male headed households, off-farm employment), and weather (temperature and rain). We explore the gender of the smallholder farmer crop selection by running maximum-likelihood multinomial logit models and use gender and other characteristics (plot, household and weather characteristics) as regressors. The objective here is to find out whether gender will be significant in explaining crop selection. As such, the multinomial logit model discrete outcome has eight categories: fruits, vegetables, legumes/pulses, grains/cereals, tubers/roots, nuts, seeds, traditional/cash and other crops. To identify the model we use the other crops category as the base outcome. The female dummy coefficient is statistically significant suggesting that the gender of the smallholder farmers determines crop selection. More specifically, the coefficient is positive and significant under grains and nuts during the long-rains season. While during the short-rains seasons, the coefficient is positive and significant for fruits and negative and significant for tubers. Under the permanent crops category, the female coefficient is positive and significant for vegetables, and negatively significant for fruits and cash crops amongst the fruit season. A positively significant female coefficient is observed for tubers and a negative and significant coefficient for fruits and seeds under the permanent crops season.

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

	Male-managed farms						Female-managed farms					
	(1) upto100	(2) upto250	(3) upto500	(4) upto1000	(5) upto2000	(6) upto3000	(7) upto100	(8) upto250	(9) upto500	(10) upto1000	(11) upto2000	(12) upto3000
Habitat share	**20,999****	**30,948****	**48,984****	**41,019****	**66,392*****	**82,201*****	**63,644****	**23,384*****	**7,580**	**17,426**	**15,024**	**-67,555**
	(7,838)	(12,660)	(20,395)	(16,695)	(18,353)	(22,560)	(20,677)	(5,082)	(21,563)	(16,183)	(24,278)	(67,624)
disthome	-162,176**	-162,173**	-162,176**	-162,178**	-162,196**	-162,204**	-5,588*	-6,349**	-6,732**	-6,507**	-6,535**	-8,591*
	(62,161)	(62,160)	(62,165)	(62,168)	(62,173)	(62,177)	(2,591)	(2,559)	(2,756)	(2,657)	(2,743)	(3,947)
distroad	42,579	42,560	42,526	42,545	42,678	42,778	9,801	10,261	10,588	10,420	10,459	11,966
	(35,815)	(35,857)	(35,881)	(35,942)	(36,072)	(36,101)	(7,779)	(7,769)	(8,080)	(7,886)	(7,954)	(9,106)
distmrkt	-4,799**	-4,793**	-4,758**	-4,785**	-4,727**	-4,687*	-1,348	-1,322	-1,320	-1,325	-1,331	-1,255
	(2,009)	(2,015)	(2,025)	(2,041)	(2,061)	(2,073)	(762.9)	(778.3)	(780.7)	(784.1)	(781.7)	(706.2)
labcost	-1.486	-1.498	-1.513	-1.509	-1.506	-1.504	-5.473	-5.472	-5.470	-5.468	-5.467	-5.496
	(6.435)	(6.443)	(6.462)	(6.457)	(6.453)	(6.451)	(5.073)	(5.101)	(5.121)	(5.117)	(5.122)	(5.175)
fertcost	-9.435**	-9.432**	-9.428**	-9.432**	-9.431**	-9.431**	0.331	0.321	0.313	0.322	0.320	0.265
	(3.523)	(3.525)	(3.527)	(3.526)	(3.525)	(3.525)	(0.392)	(0.415)	(0.416)	(0.418)	(0.417)	(0.399)
seedcost	-10.53	-10.52	-10.52	-10.52	-10.53	-10.53	2.516	2.181	2.096	2.105	2.093	1.948
	(8.405)	(8.407)	(8.408)	(8.408)	(8.407)	(8.406)	(2.459)	(2.254)	(2.172)	(2.220)	(2.232)	(2.114)
hh_age	24,839	24,934	25,107	24,961	25,089	24,931	44,251**	41,242**	41,311**	41,306**	41,160**	41,375**
	(22,994)	(22,948)	(23,182)	(23,120)	(23,408)	(23,588)	(12,856)	(13,044)	(12,214)	(12,207)	(12,326)	(13,712)
hh_age2	-331.0	-331.6	-332.3	-331.0	-329.7	-325.7	-371.4**	-353.9**	-360.3**	-358.7**	-357.8**	-376.4**
	(209.1)	(208.1)	(210.3)	(209.7)	(211.1)	(212.1)	(110.3)	(118.6)	(115.5)	(113.4)	(115.4)	(137.7)
hh_educyrs	81,295	81,345	81,174	81,349	81,444	81,597	-5,780	-6,783	-7,231	-7,039	-7,137	-9,037
	(54,779)	(54,735)	(54,665)	(54,810)	(54,722)	(54,647)	(3,734)	(3,868)	(4,081)	(3,979)	(4,019)	(4,886)
hh_occpoff	-110,641	-109,123	-108,947	-108,467	-107,053	-104,275	24,953	-1,965	-6,688	-4,108	-4,258	-30,191
	(151,784)	(152,211)	(151,071)	(151,275)	(150,640)	(150,998)	(45,012)	(34,775)	(31,783)	(32,364)	(29,717)	(21,508)
hh_mstatusdum	1.077e+06**	1.077e+06**	1.077e+06**	1.074e+06**	1.071e+06**	1.069e+06**	-163,455**	-141,001**	-136,902**	-137,554*	-136,834*	-133,142*
	(373,827)	(374,690)	(374,376)	(373,341)	(373,222)	(373,442)	(47,300)	(53,903)	(57,041)	(58,184)	(58,479)	(67,441)
temp_av_shortrain	-6.447e+06***	-6.435e+06***	-6.423e+06***	-6.417e+06***	-6.378e+06***	-6.360e+06***	2.066e+06**	2.030e+06*	2.019e+06*	2.033e+06*	2.027e+06*	1.950e+06*
	(1.203e+06)	(1.197e+06)	(1.194e+06)	(1.193e+06)	(1.185e+06)	(1.179e+06)	(862,793)	(884,915)	(873,324)	(873,426)	(873,633)	(855,358)
temp_av_shortrain2	86,844***	86,719***	86,625***	86,526***	86,130***	85,949***	-22,744**	-22,404*	-22,308*	-22,466*	-22,388*	-21,659*
	(15,760)	(15,695)	(15,676)	(15,666)	(15,589)	(15,517)	(9,597)	(9,896)	(9,793)	(9,783)	(9,798)	(9,642)
temp_av_longrain	-616,017*	-618,716*	-619,263*	-619,461*	-612,647*	-610,181*	-501,433	-481,883	-472,412	-477,428	-475,933	-434,841
	(333,784)	(335,447)	(334,754)	(334,682)	(331,642)	(330,227)	(273,640)	(272,636)	(265,144)	(267,542)	(265,374)	(243,374)
temp_av_longrain2	3,317	3,376	3,424	3,416	3,424	3,436	8,620*	8,260	8,099*	8,184*	8,166*	7,431*
	(3,572)	(3,582)	(3,564)	(3,560)	(3,545)	(3,538)	(4,428)	(4,390)	(4,260)	(4,301)	(4,256)	(3,870)
rain_av_shortrain	566,779***	567,018***	567,695***	567,431***	568,531***	569,293***	11,444	9,778	9,315	9,621	9,469	6,811
	(110,946)	(110,966)	(111,306)	(111,240)	(111,515)	(111,795)	(9,340)	(9,577)	(9,062)	(9,169)	(9,218)	(9,026)
rain_av_shortrain2	-274.3***	-275.0***	-276.0***	-275.5***	-277.2***	-278.3***	28.00***	28.68***	28.74***	28.40***	28.42**	31.74**
	(49.71)	(49.74)	(50.26)	(50.26)	(50.74)	(51.13)	(7.509)	(7.596)	(8.073)	(8.040)	(8.191)	(9.340)
rain_av_longrain	-54,507***	-54,142***	-53,482***	-53,601***	-52,020***	-51,245***	47,164*	44,969*	44,166*	44,572*	44,511*	40,875*
	(13,831)	(13,761)	(13,542)	(13,631)	(13,218)	(12,932)	(21,970)	(21,322)	(20,582)	(20,801)	(20,539)	(19,065)
rain_av_longrain2	-49.22***	-49.11***	-49.00***	-48.98***	-48.88***	-48.90***	-1.392	-0.354	-0.0874	-0.154	-0.123	0.602
	(9.018)	(8.986)	(8.923)	(8.884)	(8.858)	(8.884)	(5.865)	(5.375)	(5.081)	(5.196)	(5.128)	(4.830)
temprain_short	-10,662***	-10,662***	-10,669***	-10,666***	-10,677***	-10,685***	-549.6	-512.9	-501.2	-505.8	-502.2	-464.8
	(2,105)	(2,105)	(2,108)	(2,107)	(2,109)	(2,113)	(313.4)	(317.8)	(306.9)	(310.3)	(312.9)	(318.4)
temprain_long	1,573***	1,563***	1,547***	1,549***	1,512***	1,494***	-1,085*	-1,045*	-1,029*	-1,037*	-1,036*	-960.0*
	(361.5)	(359.9)	(354.4)	(356.1)	(346.1)	(339.7)	(465.6)	(455.7)	(441.4)	(445.4)	(440.3)	(409.3)
Constant	1.172e+08***	1.167e+08***	1.160e+08***	1.160e+08***	1.143e+08***	1.134e+08***	-4.038e+07**	-3.892e+07**	-3.846e+07**	-3.890e+07**	-3.876e+07**	-3.570e+07**
	(2.274e+07)	(2.259e+07)	(2.231e+07)	(2.236e+07)	(2.197e+07)	(2.165e+07)	(1.551e+07)	(1.551e+07)	(1.496e+07)	(1.502e+07)	(1.490e+07)	(1.380e+07)
Observations	8,931	8,931	8,931	8,931	8,931	8,931	2,512	2,512	2,512	2,512	2,512	2,512
Number of ID	3,819	3,819	3,819	3,819	3,819	3,819	1,213	1,213	1,213	1,213	1,213	1,213

Extended Data Table 4: Estimation results to predict crop revenue from pollinator-dependent crops. Estimation results from panel models estimated separately for each radius controlling for plot characteristics, production inputs, farmer characteristics, and weather. Outcome is pollinator-dependent crops revenue per hectare. Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

	Male-managed farms						Female-managed farms					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	upto100	upto250	upto100	upto250	upto100	upto250	upto100	upto250	upto100	upto250	upto100	upto250
Habitat share	**18,592***	**30,544***	**51,719***	**50,996****	**78,705****	**94,855****	**92,355****	**72,212****	**55,131*****	**48,674*****	**69,462*****	**59,017*****
	(9,433)	(15,954)	(26,533)	(21,277)	(25,664)	(33,398)	(36,134)	(29,196)	(15,382)	(6,210)	(11,951)	(6,343)
disthome	-141,075**	-141,072**	-141,075**	-141,078**	-141,099**	-141,108**	-1,976	-2,126	-2,471	-2,737	-2,089	-2,477
	(50,567)	(50,571)	(50,581)	(50,577)	(50,588)	(50,593)	(3,980)	(3,900)	(3,893)	(3,815)	(3,612)	(3,514)
distroad	35,230*	35,220*	35,189*	35,219*	35,373*	35,483*	4,101	3,959	4,268	4,550	4,115	4,428*
	(18,491)	(18,529)	(18,527)	(18,560)	(18,582)	(18,551)	(2,678)	(2,402)	(2,454)	(2,412)	(2,246)	(2,227)
distmrkt	-4,564	-4,553	-4,513	-4,530	-4,466	-4,423	-365.4*	-328.0***	-316.3***	-337.2***	-371.0**	-383.3***
	(3,193)	(3,195)	(3,195)	(3,227)	(3,231)	(3,227)	(158.4)	(54.96)	(67.51)	(87.85)	(109.8)	(100.4)
labcost	0.982	0.972	0.955	0.958	0.963	0.965	-1.597	-1.598	-1.583	-1.585	-1.576	-1.574
	(5.575)	(5.581)	(5.604)	(5.601)	(5.595)	(5.592)	(1.572)	(1.576)	(1.589)	(1.615)	(1.608)	(1.622)
fertcost	-5.887***	-5.885***	-5.880***	-5.884***	-5.883***	-5.884***	1.174	1.179	1.178	1.177	1.196	1.177
	(1.406)	(1.407)	(1.408)	(1.408)	(1.407)	(1.406)	(0.975)	(0.996)	(1.022)	(1.030)	(1.035)	(1.029)
seedcost	-12.61***	-12.60***	-12.60***	-12.61***	-12.61***	-12.62***	-1.119	-1.412	-1.535	-1.659	-1.637	-1.675
	(3.188)	(3.188)	(3.187)	(3.187)	(3.187)	(3.186)	(1.090)	(1.009)	(1.002)	(1.001)	(0.995)	(0.983)
hh_age	42,161**	42,303**	42,524**	42,481**	42,598**	42,393*	46,608*	42,328	43,059*	42,493*	42,034*	42,000*
	(18,291)	(18,247)	(18,369)	(18,422)	(18,623)	(18,854)	(21,822)	(22,819)	(21,689)	(20,562)	(20,057)	(20,210)
hh_age2	-497.9***	-498.7***	-499.8***	-499.1***	-497.4***	-492.6***	-374.0*	-337.2	-353.6*	-352.6*	-344.4*	-345.5*
	(107.8)	(107.1)	(107.8)	(108.5)	(109.9)	(112.4)	(178.4)	(189.0)	(183.9)	(176.3)	(170.8)	(174.3)
hh_educyrs	139,178**	139,232**	139,059**	139,264**	139,371**	139,540**	15,032**	14,709**	14,344**	13,789*	14,133*	13,940**
	(56,114)	(56,108)	(56,111)	(56,324)	(56,413)	(56,429)	(5,621)	(6,125)	(5,966)	(5,911)	(6,150)	(5,755)
hh_occpoff	-104,334	-103,279	-103,289	-103,193	-101,390	-98,160	111,085	83,302	77,787	75,285	83,279	80,666
	(184,368)	(184,559)	(183,333)	(183,091)	(182,133)	(181,849)	(86,625)	(74,127)	(71,550)	(71,116)	(71,834)	(69,295)
hh_mstatusdum	887,118	887,680	886,723	883,106	879,052	877,542	-150,099***	-126,750***	-120,546***	-115,458***	-116,146***	-111,265***
	(574,891)	(571,955)	(569,577)	(568,219)	(566,313)	(565,717)	(33,358)	(22,501)	(24,364)	(25,265)	(23,405)	(24,207)
temp_av_shortrain	-6.529e+06**	-6.516e+06**	-6.502e+06**	-6.488e+06**	-6.445e+06**	-6.426e+06**	1.433e+06***	1.415e+06***	1.418e+06***	1.417e+06***	1.430e+06***	1.403e+06***
	(2.192e+06)	(2.195e+06)	(2.190e+06)	(2.181e+06)	(2.171e+06)	(2.168e+06)	(305,529)	(318,106)	(311,675)	(308,777)	(307,029)	(299,577)
temp_av_shortrain2	86,850**	86,721**	86,609**	86,436**	85,987**	85,803**	-17,679***	-17,496***	-17,588***	-17,613***	-17,709***	-17,397***
	(28,046)	(28,092)	(28,053)	(27,929)	(27,819)	(27,800)	(4,155)	(4,273)	(4,177)	(4,137)	(4,120)	(4,028)
temp_av_longrain	-786,984*	-789,150*	-789,576*	-789,511*	-781,518*	-778,932*	50,484	56,864	69,526	73,271	63,750	68,988
	(352,122)	(352,947)	(351,927)	(351,409)	(350,396)	(350,015)	(215,506)	(221,415)	(228,331)	(230,431)	(229,333)	(234,123)
temp_av_longrain2	5,185	5,243	5,297	5,309	5,312	5,323	377.1	229.0	14.94	-49.45	145.9	47.03
	(4,801)	(4,794)	(4,761)	(4,749)	(4,717)	(4,700)	(2,277)	(2,349)	(2,412)	(2,437)	(2,427)	(2,499)
rain_av_shortrain	466,342**	466,662**	467,450**	467,448**	468,667**	469,465**	-15,976*	-17,085**	-17,106**	-17,759**	-17,286**	-17,659**
	(195,809)	(195,980)	(196,245)	(196,071)	(196,165)	(196,381)	(7,194)	(6,677)	(6,197)	(5,864)	(5,610)	(5,589)
rain_av_shortrain2	-226.3**	-227.1**	-228.2**	-228.2**	-230.0**	-231.2**	41.44**	41.96**	41.20**	41.27**	40.33**	40.40**
	(97.86)	(98.25)	(98.57)	(98.24)	(98.32)	(98.62)	(15.92)	(16.01)	(15.90)	(15.86)	(15.80)	(16.06)
rain_av_longrain	-55,728**	-55,260**	-54,464**	-54,221**	-52,460**	-51,677**	18,284*	16,989	15,981	15,539	16,642*	15,990*
	(21,843)	(21,594)	(21,166)	(21,132)	(20,750)	(20,475)	(9,058)	(9,186)	(8,660)	(8,401)	(8,538)	(8,044)
rain_av_longrain2	-37.32**	-37.21**	-37.09**	-37.02**	-36.92**	-36.95**	-0.744	0.155	0.545	0.824	0.654	0.787
	(16.31)	(16.28)	(16.23)	(16.20)	(16.13)	(16.08)	(8.413)	(8.220)	(7.874)	(7.713)	(7.739)	(7.599)
temprain_short	-8,772**	-8,772**	-8,781**	-8,781**	-8,793**	-8,801**	-6.482	16.89	25.69	42.02	38.43	47.24
	(3,648)	(3,649)	(3,652)	(3,650)	(3,651)	(3,653)	(225.8)	(227.9)	(213.7)	(208.1)	(205.7)	(204.2)
temprain_long	1,492**	1,480**	1,460**	1,454**	1,412**	1,394**	-445.8**	-425.2**	-405.2**	-397.6**	-420.9**	-407.1**
	(594.9)	(588.9)	(578.2)	(576.9)	(567.1)	(560.1)	(159.8)	(164.9)	(155.7)	(150.9)	(154.1)	(143.8)
Constant	1.258e+08***	1.253e+08***	1.244e+08***	1.241e+08***	1.222e+08***	1.213e+08***	-3.133e+07**	-3.046e+07**	-3.035e+07**	-3.020e+07**	-3.092e+07**	-3.025e+07**
	(3.196e+07)	(3.179e+07)	(3.145e+07)	(3.139e+07)	(3.107e+07)	(3.082e+07)	(9.214e+06)	(9.376e+06)	(9.400e+06)	(9.324e+06)	(9.341e+06)	(9.020e+06)
Observations	8,931	8,931	8,931	8,931	8,931	8,931	2,512	2,512	2,512	2,512	2,512	2,512
Number of ID	3,819	3,819	3,819	3,819	3,819	3,819	1,213	1,213	1,213	1,213	1,213	1,213

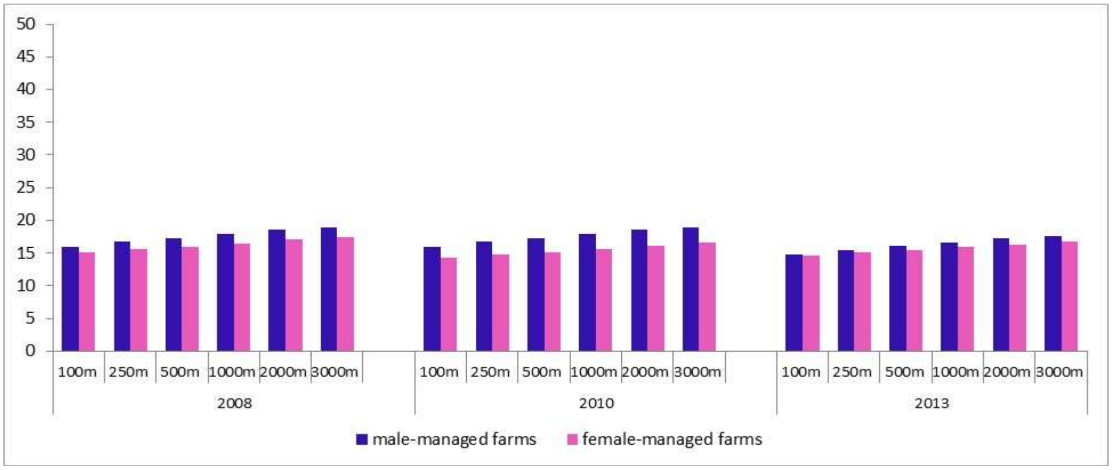
Extended Data Table 5: Estimation results from panel regression models to predict crop revenue from all crops. Estimation results from panel regression models estimated separately for each radius controlling for plot characteristics, production inputs, farmer characteristics, and weather. Outcome is all crops revenue per hectare. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

	Male-managed farms						Female-managed farms					
	(1) upto100	(2) upto250	(3) upto100	(4) upto250	(5) upto100	(6) upto250	(7) upto100	(8) upto250	(9) upto100	(10) upto250	(11) upto100	(12) upto250
Habitat share	**1,290***	**2,734***	**4,589**	**6,721****	**7,045*****	**7,197****	**588.7**	**-557.5**	**-1,428**	**-472.1**	**-320.9**	**2,803**
	(664.7)	(1,383)	(2,624)	(2,369)	(2,152)	(2,677)	(795.7)	(768.3)	(1,821)	(2,553)	(3,671)	(3,847)
disthome	-224.3*	-224.1*	-224.4*	-224.9*	-226.5*	-226.9*	1,171	1,145	1,121	1,147	1,150	1,227
	(113.8)	(113.6)	(113.9)	(113.9)	(113.4)	(113.3)	(926.7)	(940.1)	(905.4)	(937.3)	(1,018)	(991.1)
distroad	5,037	5,038	5,035	5,040	5,051	5,057	2,604***	2,625***	2,644***	2,622***	2,619***	2,563***
	(4,578)	(4,578)	(4,579)	(4,585)	(4,590)	(4,584)	(654.6)	(660.5)	(615.6)	(621.2)	(677.7)	(645.5)
distmrkt	-447.8	-446.1	-442.6	-440.9	-438.2	-436.9	-450.3*	-450.1*	-450.3*	-450.0*	-449.9*	-452.8**
	(351.0)	(351.7)	(351.6)	(347.0)	(344.6)	(346.4)	(191.8)	(191.4)	(191.5)	(191.2)	(190.4)	(188.3)
labcost	0.410	0.409	0.408	0.407	0.408	0.409	0.340	0.340	0.340	0.340	0.340	0.341
	(0.542)	(0.541)	(0.542)	(0.542)	(0.541)	(0.541)	(0.324)	(0.323)	(0.323)	(0.323)	(0.323)	(0.323)
fertcost	-0.266	-0.266	-0.266	-0.266	-0.266	-0.266	0.534	0.533	0.532	0.533	0.533	0.535
	(0.411)	(0.411)	(0.410)	(0.410)	(0.410)	(0.410)	(0.469)	(0.469)	(0.471)	(0.470)	(0.468)	(0.469)
seedcost	-0.392	-0.391	-0.391	-0.392	-0.392	-0.392	-2.024**	-2.031*	-2.034*	-2.029*	-2.029*	-2.023*
	(0.416)	(0.416)	(0.415)	(0.415)	(0.416)	(0.416)	(0.856)	(0.863)	(0.862)	(0.865)	(0.867)	(0.865)
hh_age	4,951	4,972	4,991	5,019	4,998	4,971	-4,571	-4,601	-4,623	-4,603	-4,599	-4,607
	(3,125)	(3,126)	(3,139)	(3,149)	(3,160)	(3,163)	(2,808)	(2,784)	(2,801)	(2,804)	(2,810)	(2,770)
hh_age2	-51.32	-51.46	-51.55	-51.68	-51.34	-50.94	50.08**	50.00**	50.03**	50.11**	50.10**	50.81**
	(33.93)	(33.91)	(34.09)	(34.20)	(34.26)	(34.37)	(19.17)	(19.22)	(18.94)	(19.22)	(19.88)	(19.63)
hh_educyrs	3,257	3,263	3,248	3,271	3,275	3,285	-2,859	-2,891*	-2,920	-2,886	-2,882	-2,810
	(5,795)	(5,801)	(5,805)	(5,783)	(5,782)	(5,780)	(1,525)	(1,525)	(1,586)	(1,590)	(1,546)	(1,585)
hh_occpoff	4,254	4,271	4,272	4,164	4,440	4,698	12,323	11,846	11,602	11,882	11,912	12,895
	(5,372)	(5,393)	(5,483)	(5,594)	(5,517)	(5,456)	(16,130)	(15,868)	(16,439)	(16,103)	(15,136)	(15,019)
hh_mstatusdum	33,380	33,370	33,287	32,663	32,597	32,634	2,676	3,070	3,226	2,995	2,967	2,843
	(21,399)	(21,071)	(20,816)	(20,561)	(20,689)	(20,558)	(10,094)	(10,075)	(9,609)	(9,722)	(10,025)	(10,077)
temp_av_shortrain	-108,398	-107,119	-105,911	-102,536	-100,727	-100,588	333,488	332,477	331,232	332,324	332,601	335,437
	(210,217)	(209,982)	(210,765)	(211,512)	(211,423)	(212,515)	(183,027)	(183,393)	(186,357)	(185,127)	(181,228)	(181,686)
temp_av_shortrain2	1,383	1,370	1,361	1,325	1,305	1,303	-4,777*	-4,767*	-4,754*	-4,765*	-4,768*	-4,795*
	(3,072)	(3,067)	(3,074)	(3,084)	(3,084)	(3,095)	(2,269)	(2,275)	(2,305)	(2,293)	(2,253)	(2,260)
temp_av_longrain	-194,914	-195,020	-195,060	-194,976	-194,337	-194,275	-5,714	-5,088	-4,662	-5,165	-5,249	-6,803
	(238,281)	(238,326)	(238,261)	(238,055)	(238,043)	(238,203)	(91,776)	(91,559)	(91,973)	(91,110)	(90,014)	(89,507)
temp_av_longrain2	1,810	1,815	1,820	1,826	1,821	1,820	273.6	262.7	255.4	264.0	265.2	293.0
	(2,317)	(2,316)	(2,312)	(2,308)	(2,310)	(2,309)	(938.8)	(933.7)	(937.7)	(923.7)	(906.2)	(898.8)
rain_av_shortrain	-6,841	-6,798	-6,728	-6,649	-6,618	-6,599	-82.21	-124.1	-168.4	-122.4	-115.5	-15.08
	(3,787)	(3,806)	(3,844)	(3,823)	(3,800)	(3,840)	(3,296)	(3,253)	(3,173)	(3,166)	(3,200)	(3,188)
rain_av_shortrain2	-1.207	-1.288	-1.391	-1.500	-1.554	-1.581	-2.246	-2.230	-2.195	-2.222	-2.225	-2.352
	(1.791)	(1.821)	(1.859)	(1.757)	(1.717)	(1.776)	(1.556)	(1.535)	(1.474)	(1.462)	(1.503)	(1.484)
rain_av_longrain	-2,588	-2,527	-2,457	-2,330	-2,276	-2,274	408.8	350.3	311.5	357.3	362.9	499.8
	(3,154)	(3,175)	(3,231)	(3,251)	(3,229)	(3,273)	(987.7)	(1,034)	(999.1)	(1,060)	(1,171)	(1,179)
rain_av_longrain2	2.915**	2.924**	2.935**	2.954**	2.951**	2.943**	-0.169	-0.147	-0.136	-0.151	-0.153	-0.180
	(1.119)	(1.114)	(1.109)	(1.104)	(1.109)	(1.104)	(0.326)	(0.339)	(0.313)	(0.324)	(0.353)	(0.350)
temprain_short	148.7**	148.4**	147.7**	146.8**	146.6**	146.4**	18.57	19.51	20.31	19.38	19.24	17.84
	(51.85)	(51.96)	(52.36)	(52.35)	(52.16)	(52.47)	(67.14)	(66.26)	(64.73)	(64.74)	(65.44)	(65.40)
temprain_long	18.28	16.80	15.06	11.93	10.73	10.75	-1.705	-0.563	0.223	-0.688	-0.805	-3.665
	(51.81)	(52.31)	(53.66)	(54.30)	(53.75)	(54.73)	(18.97)	(19.85)	(19.20)	(20.50)	(22.78)	(22.94)
Constant	7.034e+06	6.971e+06	6.897e+06	6.763e+06	6.697e+06	6.687e+06	-5.470e+06*	-5.432e+06*	-5.392e+06	-5.429e+06	-5.437e+06*	-5.552e+06*
	(8.880e+06)	(8.895e+06)	(8.944e+06)	(8.954e+06)	(8.933e+06)	(8.993e+06)	(2.837e+06)	(2.846e+06)	(2.936e+06)	(2.941e+06)	(2.848e+06)	(2.863e+06)
Observations	8,931	8,931	8,931	8,931	8,931	8,931	2,512	2,512	2,512	2,512	2,512	2,512
Number of ID	3,819	3,819	3,819	3,819	3,819	3,819	1,213	1,213	1,213	1,213	1,213	1,213

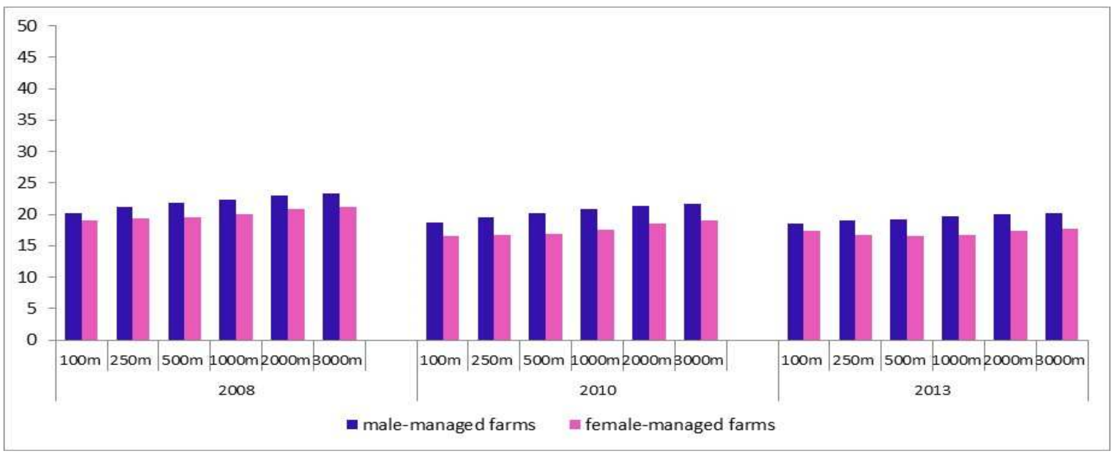
Extended Data Table 6: Estimation results to predict crop revenue from pollinator-independent crops Estimation results from panel models estimated separately for each radius controlling for plot characteristics, production inputs, farmer characteristics, and weather. Outcome is pollinator-independent crops revenue per hectare. Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

	Male-managed farms	Female-managed farms	Mean difference
Plot revenue p/a (all crops)	472294.80	297773.60	174521.20
Plot revenue p/a (pollinator-dependent crops)	263031.70	153913.50	109118.20
Plot revenue p/a (pollinator-independent crops)	111788.90	83605.51	28183.39
Size of plot (ha)	2.95	2.01	0.94***
Distance to home	2.51	2.40	0.11
Distance to road	1.64	1.61	0.03
Distance to market	10.07	8.95	1.12***
Cost of labour	8131.33	5659.41	2471.92***
Cost of fertilisers	7648.73	4740.10	2908.63***
Cost of seedlings	2790.26	1637.88	1152.38**
Head of household-age	47.92	56.09	-8.17***
Head of household-education years	8.90	8.49	0.41***
Head of household-off-farm job	0.13	0.08	0.05***
Number of livestock	25.61	18.31	7.31***
Extension advice	0.21	0.18	0.03***
Soil quality, good	0.47	0.44	0.02***
Slope, steep	0.34	0.30	0.04***
Temperature (short-rains)	40.40	40.69	-0.29
Temperature (long-rains)	42.57	42.77	-0.20
Rainfall (short-rains)	141.07	138.35	2.72***
Rainfall (long-rains)	183.47	187.57	-4.09***
Share of wild pollinator natural habitats (%) 100m	15.36	14.63	0.73***
Share of wild pollinator natural habitats (%) 250m	16.06	15.11	0.96***
Share of wild pollinator natural habitats (%) 500m	16.65	15.49	1.16***
Share of wild pollinator natural habitats (%) 1000m	17.26	15.94	1.31***
Share of wild pollinator natural habitats (%) 2000m	17.88	16.46	1.42***
Share of wild pollinator natural habitats (%) 3000m	18.25	16.84	1.40***

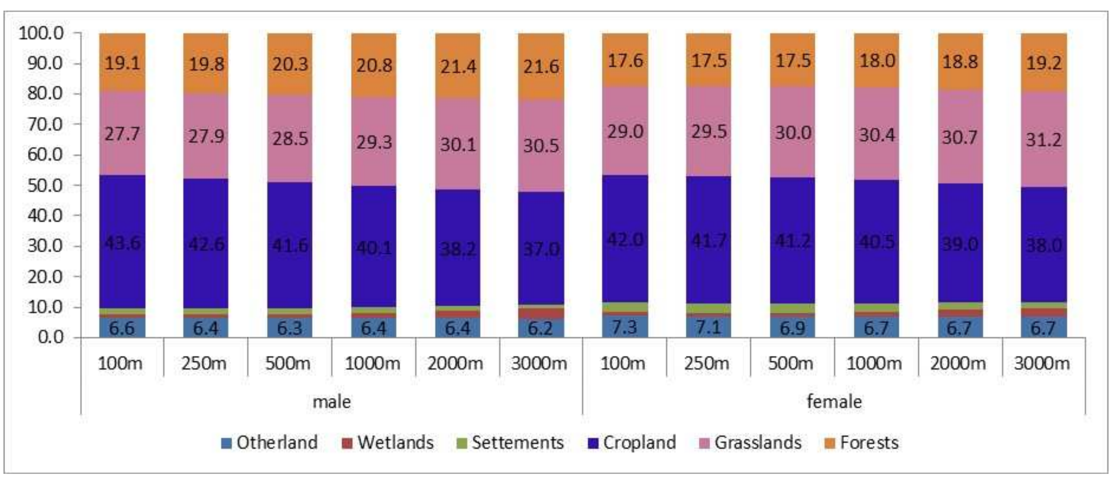
Extended Data Table 7: Descriptive Statistics. The table **shows** the summary statistics. *** p<0.01, ** p<0.05, * p<0.1



Extended Figure 1: % Share of forest cover around male- and female-managed farms in different buffers. This shows the average share of forest cover in 100m, 250m, 500m, 1000m, 2000m and 3000m radius buffers in 2008-2013 around male- and female-managed farms using the Hansen et al. (2013) land cover maps.



Extended Figure 2: % Share of forest cover around male- and female-managed farms in different buffers – robust checks with SERVIR land cover. This shows the average share of forest cover in 100m, 250m, 500m, 1000m, 2000m and 3000m radius buffers in 2008-2013 around male- and female-managed farms using the SERVIR land cover maps.



Extended Figure 3: % Share of different land cover around male- and female-managed farms in different buffers with SERVIR land cover. This shows the average share of different land cover in 100m, 250m, 500m, 1000m, 2000m and 3000m radius buffers in 2008-2013 around male- and female-managed farms using the SERVIR land cover maps.