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Farm size, food security, and welfare: Descriptive evidence from the Ethiopian highlands

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

A growing rural population combined with limited scope for further land expansion and slow movement out of agriculture means that average farm sizes are decreasing in Ethiopia. In this exploratory analysis, we study what this might mean for the food security and welfare of farming households. Using cross-sectional data for the Ethiopian highlands, we find – surprisingly – small differences between owners of small and large farms in key welfare and food security outcomes. For example, we find that a 20-percent increase in owned land area is associated with only a 0.7 percent increase in food consumption. Five adjustments are made by households residing on small farms to assure similar calorie intake as those residing on larger farms. First, they participate actively in land rental markets and, as a result, are able to double their cultivated land area, on average. Second, they compensate their small landholdings with other income sources, mainly livestock and non-farm businesses, permitting additional food purchases. Third, they cultivate their land more intensively, obtaining higher yields. Fourth, they favor more calorie-dense crops that are mostly used for own consumption. Fifth, they produce as well as consume cheaper food items.

1. INTRODUCTION

Understanding the consequences of decreasing land availability per capita because of population growth is of considerable interest to policy makers. Already in the 19th century, there were worries voiced about the effects of population growth on food security. Malthus (1826) famously predicted that the planet would run out of food because of increasing land constraints and that population growth was therefore to be controlled. However, technological changes in agriculture have since contributed to substantial increases in agricultural production per unit of land, and no global food shortages have occurred. Available evidence in different settings, including Africa, shows that population growth has induced agricultural change and led to a reduction in fallow periods, to adoption of agricultural innovations, and an increase in input use – labor and other agricultural inputs – per unit of land, all leading to higher yields (Boserup 2005; Fresco 1986; Binswanger and Pingali 1988; Tsakok 2011; Jayne, Chamberlin, and Headey 2014; Headey and Jayne 2014; Ricker-Gilbert, Jumbe, and Chamberlin 2014; Muyanga and Jayne 2014; Headey, Dereje, and Taffesse 2014; Josephson, Ricker-Gilbert, and Florax 2014; Lipton 1980, 2006).

Still, there must be limits to increases in agricultural output per unit of land. If true, then an important question arises on how shrinking farms can provide a decent livelihood for households residing on these farms. Given rural population growth and the importance of agriculture in providing livelihoods, especially in most African countries, there is a considerable interest in understanding the linkages between declining farm sizes and welfare and food security outcomes.

Making progress on this topic, however, is difficult due to data constraints. Establishing causal relationship between land size and welfare requires a natural experiment; for example, a policy reform that re-allocates agricultural land across households. Such natural experiments are hard to come by. Moreover, if they do take place, they are often accompanied by other drastic changes in the society, e.g. a civil war or a revolution, making it difficult to isolate the impact of the land reform from other factors shaping the society. Therefore, most existing studies make use of cross-sectional or longitudinal data sets to establish descriptive patterns, rather than causal relationships, e.g. Headey, Dereje, and Taffesse (2014) in Ethiopia; Muyanga and Jayne (2014) in Kenya.

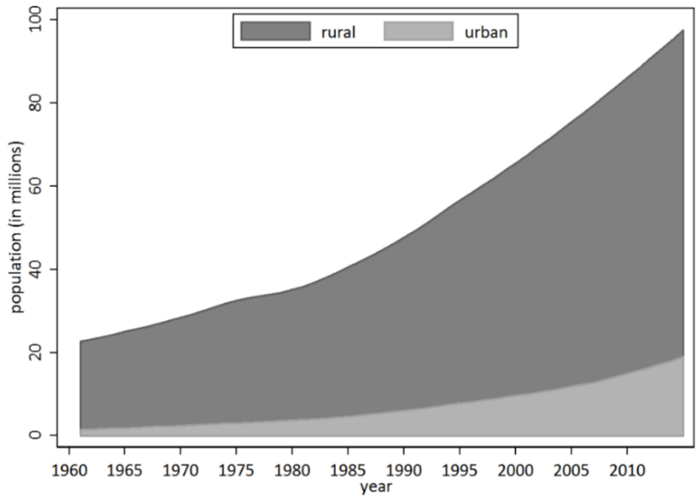
We revisit these questions using a rich cross-sectional survey from rural Ethiopia. Research on this question is important for Ethiopia given rapid population growth and limited urbanization. A large – and rapidly growing – population means that more and more people are going to reside in rural areas. For example, ISS (2017) projects that the rural population in Ethiopia will grow by 26 million people – a number higher than the current population of Australia – between 2016 and 2030, an increase of 32 percent (from 80 to 106 million). The scope for further land expansion seems limited. Recent analysis by Bachewe et al. (2017) shows how the rate of agricultural land expansion has decreased over the last decade. Unless the rate at which people move out of agriculture increases considerably, the average land size owned by households is going to decrease (Masters et al. 2013). This increasing lack of available land, especially for younger generations, is a major concern for all stakeholders concerned about livelihoods and food security in Ethiopia.

Previous work in this area in Ethiopia has focused on assessing how land constraints or population density shape agricultural intensification. We focus on the question of how land sizes are associated with household welfare and food security outcomes. We find surprisingly minor differences in key welfare outcomes such as food consumption and food security between small and large farms. We document five adjustments made by small farms to assure similar caloric intake as for households living on large farms. First, they participate actively in land rental markets and, in this way, double their cultivated land compared to owned land, i.e., for the smallest quintile from 0.25 to 0.5 hectares. Second, they compensate their small landholdings with other income sources, mainly livestock and non-farm businesses, that allow for additional food purchases. Third, they cultivate their land more intensively. Fourth, they switch to bulkier and more calorie-dense crops that are mostly used for own consumption. Fifth, they produce as well as consume cheaper food items.

2. BACKGROUND

The last two decades have been characterized by high population growth in Ethiopia. The population grew by 4.1 percent per year over the period 1994 to 2007, but this rate has decreased to 2.5 percent over the period 2007 to 2015. While urban growth rates are higher than in rural areas (4.6 versus 2.1 percent, respectively, between 2007 and 2015), the growth in absolute population numbers in rural areas is still considerably higher than in urban areas. Figure 1 shows that the rural population grew by 40 million people and doubled to 80 million people in the last 30 years. Over the same period, the urban population increased from 1.5 to 19 million. Even though the urban population is expected to grow faster in the future, projections put the rural population at 106 million (26 million more than in 2016), constituting 74 percent of the total population in 2030 (World Bank 2015).

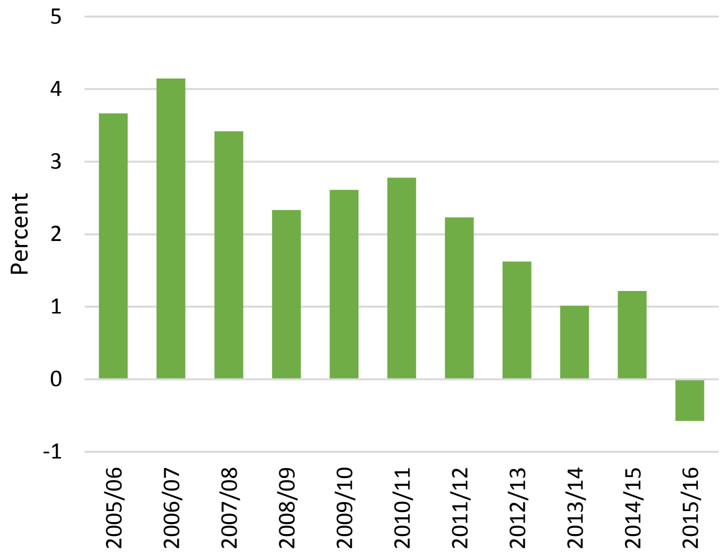
Figure 1: Population growth in Ethiopia, 1961 to 2015, by rural and urban



Source: Authors' calculation from World Bank (2017) data.

Most rural residents depend on agriculture as their main source of livelihood (Schmidt and Bekele 2016; Bachewe et al. 2017). Access to land for agricultural activities is crucial. However, there seems to be limits to increasing agricultural land area, as Figure 2 suggests. The Ethiopian Central Statistical Agency (CSA) estimated that land expanded by more than 4 percent in 2006/07, but that the land expansion rate has come down gradually over the next decade. The rapid growth in rural population and the slower growth in cultivated land area implies that the already small farm sizes are further decreasing in Ethiopia.

Figure 2: Growth of cultivated agricultural area in Ethiopia, 2005/06 to 2015/16, percent



Source: Authors' calculation from CSA data.

3. DATA AND DESCRIPTIVE STATISTICS

The data used in this study are from nearly 7,000 households resident in five regions of the country: Amhara; Oromia; Tigray; Southern Nations, Nationalities, and Peoples (SNNP); and Somale. These data were collected by the CSA with support from the International Food Policy Research Institute to evaluate the impact of the Feed the Future (FtF) investments in Ethiopia. We use the midline data collected in June/July 2015 and focus on the highland regions of the country: Amhara, Oromia, Tigray and SNNP. Of these households, 5,609 own farm land, and the sample used in this study is restricted to these households. The geographical coverage of the sample is wide with the survey having been implemented in 252 *kebeles* (sub-districts, the lowest administrative unit) in 84 *woredas* (district). Still, despite this it is worth noting that the sample is not nationally representative. Bachewe et al. (2014) provide more information about these data.

We begin by dividing household landholdings into five quintiles according to size. Table 1 shows that the average household in the 1st quintile owns 0.25 hectares of land. This increases to nearly 3 hectares in the 5th quintile.

Table 1: Land ownership distributions, by quintile, hectares

Land quintile:	1st	2nd	3rd	4th	5th
Minimum	0.01	0.48	0.75	1.13	1.88
Mean	0.25	0.60	0.94	1.48	2.93
Median	0.25	0.56	1.00	1.50	2.54
Maximum	0.48	0.75	1.13	1.88	12.97

Source: Authors' calculation from Feed the Future 2015 midline survey data.

By construction, each quintile has 20 percent of the households in the full sample. However, average farm sizes vary across regions raising a concern that a land quintile is dominated by households in one region. If so, the assessment of welfare differences across land quintiles is confounded by welfare differences across regions. In Table 2 we see that defining the quintiles using the full sample works reasonably well also within the regions. For example, in Tigray, the distribution of households is close to 20 percent in each quintile. Households in Oromia are somewhat over-represented in the 5th quintile while households in SNNP are somewhat over-represented at the bottom quintiles. We conclude that welfare differences across land quintiles are unlikely to only reflect regional differences. However, mindful of this, we will verify our core findings with simple regressions that net out regional differences.

Table 2: Percent of households in each land ownership quintile, by region

Land quintile:	1st	2nd	3rd	4th	5th	Total
Tigray	21	20	20	18	21	100
Amhara	17	18	23	24	18	100
Oromia	15	16	20	22	28	100
SNNP	30	28	19	13	10	100
Total	20	20	20	20	20	100

Source: Authors' calculation from Feed the Future 2015 midline survey data.

We next study how basic household characteristics differ across the land distribution. Table 3 shows that households with smaller landholdings are, on average, younger and somewhat more likely to have dependents, i.e., household members less than 16 or more than 61 years old (see also Headey and Jayne 2014). Household size increases with land size. Education levels are extremely low and there are no clear patterns across the land distribution. Interestingly, more than 12 percent of the households in the top quintile are model farmers, the farmers that extension agents use as role models for other farmers, while the corresponding figure in the bottom quintile is less than 3 percent.

Table 3: Household characteristics, by land ownership quintile

Land quintile:	1st	2nd	3rd	4th	5th
Age of head, years	40.3	43.0	44.4	46.6	49.4
Young-headed households, %	40.3	30.9	28.5	21.1	17.9
Female-headed households, %	31.8	30.2	28.5	23.8	20.8
Dependency ratio	0.66	0.65	0.64	0.61	0.60
Education of the head, in years	1.73	1.75	1.56	1.41	1.60
Household size, adult equivalent	3.44	3.84	4.12	4.39	4.88
Household size, number	4.37	4.79	5.10	5.33	5.82
Model farmers, %	2.9	4.3	5.6	8.1	12.1

Source: Authors' calculation from Feed the Future 2015 midline survey data.
Note: Young-headed = households headed by an individual 15 to 34 years old. Dependency ratio = (number of less than 16 years+ above 61 years old)/(household size)

In Table 4 we look at land characteristics across the land distribution. As expected, the average number and the size of plots increase with overall farm size. All land in Ethiopia, in principle, is owned by the state. More specifically, individual farmers enjoy all the rights of the owner, but cannot officially sell the land (Ambaye 2012; Deininger et al. 2008). As a result, land in Ethiopia is mostly acquired through inheritance from parents or by community allocation (Ghebru, Koru, and Taffesse 2016). In our dataset, more than 75 percent of the land owned by households in the first quintile is inherited. This decreases to 40 percent in the top land quintile. Interestingly, a larger fraction of the land owned by households in the top quintile has been allocated by the community.

Table 4: Land characteristics, by land ownership quintile

Land quintile:	statistic	1st	2nd	3rd	4th	5th
Number of plots	mean	3.6	4.0	4.5	5.3	6.2
	median	3	4	4	5	6
Average size of plots, hectare	mean	0.17	0.21	0.26	0.31	0.44
	median	0.12	0.17	0.21	0.25	0.38
Fertile land, %	mean	68.8	66.4	65.4	63.8	66.8
Flat sloped land, %	mean	69.0	69.0	68.1	68.4	70.2
Number of plots in *belg*, %	mean	16.0	16.3	13.2	13.2	12.2
Area cultivated in *belg*, %	mean	15.5	15.3	12.1	12.2	11.5
Percent of land irrigated, %	mean	1.2	2.7	1.9	1.7	1.4
Percent of land inherited, %	mean	76.6	68.9	59.4	52.7	42.2
Percent of land allocated by community, %	mean	17.0	26.1	35.4	41.4	52.4

Source: Authors' calculation from Feed the Future 2015 midline survey data.

When we look at a number of land quality measures, we note that households at the bottom quintile are somewhat more likely to report having fertile or flat sloped land than other households, but the differences across the land distribution are marginal. Interestingly, the short rainy season (*belg*) is relatively more important for households who own less land. But again, the differences are quite marginal; the long rainy season (*meher*) is the dominant cropping season for most households. The use of irrigation is extremely low across all households, and there is no clear pattern across land quintiles.

Overall, these descriptive results suggest that there are few differences in land quality between small and large farms. Therefore, in what follows, we will not make adjustments for differences in land quality.

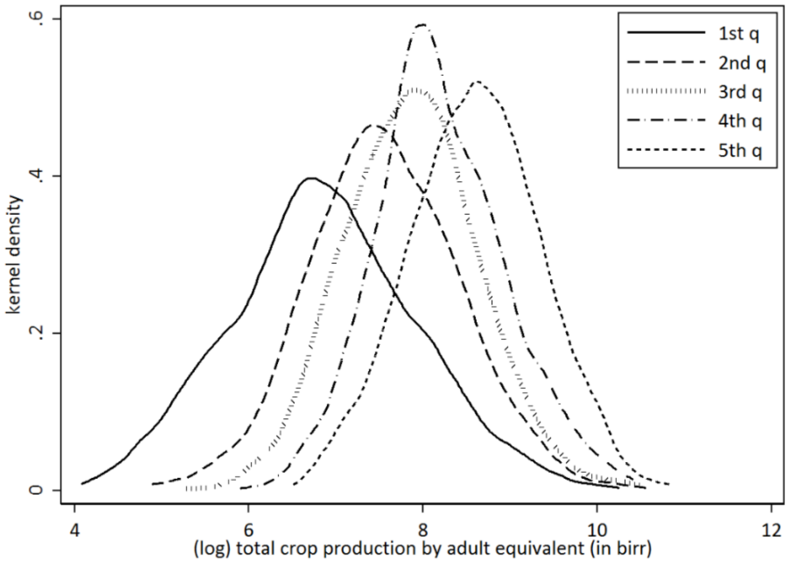
4. FARM SIZE, CROP INCOME, AND WELFARE

We start our analysis with looking at how crop income varies over land quintiles. Table 5 shows how total agricultural production – measured either in birr or in calories per adult equivalent – increases sharply with farm size. Across the board, mean values are considerably larger than medians, suggesting that these crop income distributions are skewed to the right, i.e. a small number of very high values. The median household at the bottom land quintile produced 941 birr per adult equivalent worth of crops over the two cropping seasons in 2014/15. The median household at the top quintile produced nearly six times as much (5,524 birr). This result holds if one controls for regional differences in a regression framework (results available upon request). However, it is worth noting that these averages mask considerable dispersion within the land quintiles. Figure 3 shows the full crop income distributions by land quintile. The dispersion of crop income is particularly high among households in the bottom quintile.

Another way of aggregating crop production is to measure them in terms of calories using calorie conversion factors.[1] The mean and median total kilocalories produced per day per adult equivalent are reported in the bottom rows of Table 5. As before, we see that the number of calories produced increases with land size, but the gradient is not as steep as when the monetary measure is used. Production in calories produced per adult equivalent is only 2.5 times as high for the highest quintile, compared to six times in value terms. This suggests that households with smaller landholdings focus on producing food items that are less valuable in monetary terms but contain relatively more calories.

[1] We thank the Ethiopian Public Health Institute (EPHI), Mulugeta Tilahun, and Roseline Remans for sharing these conversion factors with us.

Figure 3: Distributions of total annual crop production by land ownership quintile, birr per adult equivalent



Source: Authors' calculation from Feed the Future 2015 midline survey data.

Table 5: Total annual crop production, per adult equivalent, by land ownership quintile

Land quintile:	statistic	1st	2nd	3rd	4th	5th
Total crop production (in birr)	mean	1,706	2,848	3,573	4,817	7,123
	median	941	1,844	2,620	3,411	5,524
Total calorie production (in kcal, per day)	mean	2,423	2,728	3,055	3,757	4,879
	median	1,501	1,895	2,283	2,971	3,769

Source: Authors' calculation from Feed the Future 2015 midline survey data.

Nevertheless, we note important differences in crop output for both measures, and we explore next how these large differences in crop output translate into differences in welfare, consumption, and food security. Table 6 presents the results of these calculations. We see surprisingly small differences across the land quintiles. In fact, the average (mean and median) food consumption levels are higher among households in the bottom quintiles compared to those in the top quintile. This suggests a negative gradient across the land distribution. However, the opposite is true for non-food consumption: the average (mean and median) non-food consumption levels are highest in the top land quintals. Interestingly, we also see that the average household size (in adult equivalents) increases steadily as we move up the land quintiles.

Table 6: Welfare indicators, by land ownership quintile

Land quintile:	statistic	1st	2nd	3rd	4th	5th
Per adult equivalent consumption, birr	mean	7,018	6,542	6,417	6,222	6,119
	median	5,749	5,493	5,425	5,369	5,242
Per adult equivalent food consumption, birr	mean	6,248	5,818	5,656	5,416	5,168
	median	5,080	4,846	4,692	4,600	4,370
Per adult equivalent non-food consumption, birr	mean	770	724	761	806	951
	median	510	483	543	594	761
Non-food consumption out of total consumption, %	mean	11.5	11.6	12.4	13.4	16.0
	median	8.9	9.1	10.1	11.5	14.3
Calorie consumption per adult equivalent per day	mean	3,703	3,736	4,024	3,717	4,149
	median	2,904	2,910	2,993	3,037	3,154
Household size, adult equivalents	mean	3.4	3.8	4.1	4.4	4.9
	median	3.3	3.7	4.0	4.3	4.7
Number of months of food shortage	mean	0.86	0.77	0.56	0.49	0.35
Food shortage during the rainy season,%	mean	19.6	17.8	14.5	11.5	7.7
Stunting among children,%	mean	50.1	47.7	49.0	49.0	45.6

Source: Authors' calculation from Feed the Future 2015 midline survey data.
Note: All consumption values (except calorie consumption) are expressed in annual terms

In Table 7, we study these surprising gradients further in a regression framework. Specifically, we include a household size variable as well as binary indicator variables for each region to control for differences in household size and across regions. Once we add these controls, the coefficients on the land size variable turn positive, suggesting that the negative consumption gradients observed in Table 6 are driven by differences in household size or differences across regions. However, of equal note is that the slope of the gradient is quite flat: a 20 percent increase in land size is associated with only a 0.9 percent increase in household total consumption and an even lower 0.7 percent increase in food consumption.

Table 7: Welfare indicators – controlling for household size and regional differences, by land ownership quintile

	1	2	3	4	5	6	7	8
dependent variable:	(log) annual per adult equivalent consumption		(log) annual per adult equivalent food consumption		(log) annual per adult equivalent non-food consumption		non-food consumption out of total consumption	
(log) land owned (hectares)	-0.052***	0.047***	-0.069***	0.037***	0.123***	0.178***	0.171***	0.127***
	(0.008)	(0.006)	(0.008)	(0.006)	(0.019)	(0.020)	(0.017)	(0.017)
household size in adult equivalent units		-0.205***		-0.215***		-0.123***		0.081***
		(0.003)		(0.003)		(0.010)		(0.009)
Region dummies?	No	Yes	No	Yes	No	Yes	No	Yes
R^2	0.008	0.434	0.013	0.446	0.008	0.040	0.019	0.039

Source: Authors' calculation from Feed the Future 2015 midline survey data. Observations: 5,609.
Note: robust standard errors in parentheses.

The bottom part of Table 6 looks at food insecurity. We see that households with larger landholdings are less likely to report food insecurity. The average household in the lowest quintile had 0.86 months of food shortage in the 12 months preceding the interview. This reduces to 0.35 in the top land quintile. Similarly, nearly 20 percent of households in the bottom quintile report having experienced food shortage in the previous rainy season, while the corresponding figure in the top quintile is nearly 8 percent. Finally, about half of children residing in households in the bottom quintile are stunted (short for their age). This stunting prevalence falls only by 4 percentage points as we move to the top quintile.

These tabulations and simple regressions suggest that land size is associated with considerably higher crop income. However, these crop income gains are not translated into better consumption outcomes. While households with larger landholdings report less food insecurity, the differences are not as large as one would expect based on income differences. Moreover, chronic undernutrition (stunting) rates are similar across the land quintiles.[2] Together, these are quite surprising findings. In order to be sure that this is not just some artefact of our data, we verified this finding using nationally representative data collected by the CSA together with the World Bank through the Ethiopian Socioeconomic Survey 2013/14 (CSA and the World Bank 2013). The Appendix replicates Tables 1, 5, 6 and 7 using these data. The results are remarkably similar: a large gradient in crop income with increasing landholding size, but a negligible one in welfare (consumption) outcomes. The remainder of the paper attempts to understand these puzzling findings.

5. WHAT ARE HOUSEHOLDS WITH SMALL LAND SIZES DOING DIFFERENTLY?

5.1. Land rental

The analysis presented above shows that land sizes increase by more than ten-fold when we move from the first land quintile to the fifth (Table 1). At the same time, calorie production per adult equivalent only doubles (Table 5). One possible explanation is that households have access to rental markets and compensate lack of owned land with rental land. Table 8 explores this. We see that an average household in the bottom quintile rents in about 0.30 hectares of land. This rental land doubles the total operated land size in this quintile. However, even after this, an average household in the bottom quintile operates less land than an average household in the 2nd quintile owns. Importantly, the ranking of the quintiles remains the same if we considered net operated land instead of owned land.

Table 8: Owned land versus operated land size, by land ownership quintile, hectares

Land quintile:	1st	2nd	3rd	4th	5th
Owned land size	0.25	0.60	0.94	1.48	2.93
Rented in	0.30	0.18	0.17	0.20	0.24
Rented out	0.06	0.10	0.14	0.23	0.36
Net operated land size	0.49	0.68	0.97	1.44	2.81

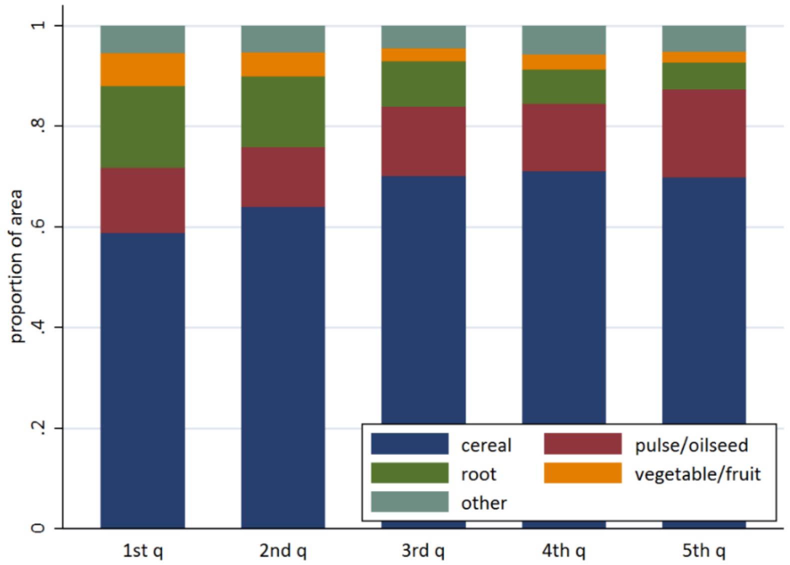
Source: Authors' calculation from Feed the Future 2015 midline survey data.

5.2. Crop choice

Another hypothesis is that households with smaller landholdings favor more calorie-dense crops. Figure 4 shows the land area allocated to different crops by land quintile. As expected (Taffesse, Dorosh, and Gemessa 2012), cereals dominate crop portfolios across all land quintiles. Cereals account for nearly 60 percent of the cultivated land area in the 1st land quintile and about 70 percent in the 5th land quintile. Interestingly, root crops – about half of this is due to enset (false banana) – are relatively more important at the bottom quintiles. Given the importance of cereals in the overall crop production, we next zoom into their composition. Figure 5 shows two interesting patterns. First, the importance of maize decreases as we move from the bottom land quintiles to the top quintiles. Second, the opposite pattern emerges for teff. It is of note that out of the main cereals cultivated and consumed in Ethiopia, maize is the most and teff is the least energy (kcal) dense (Baye 2014).

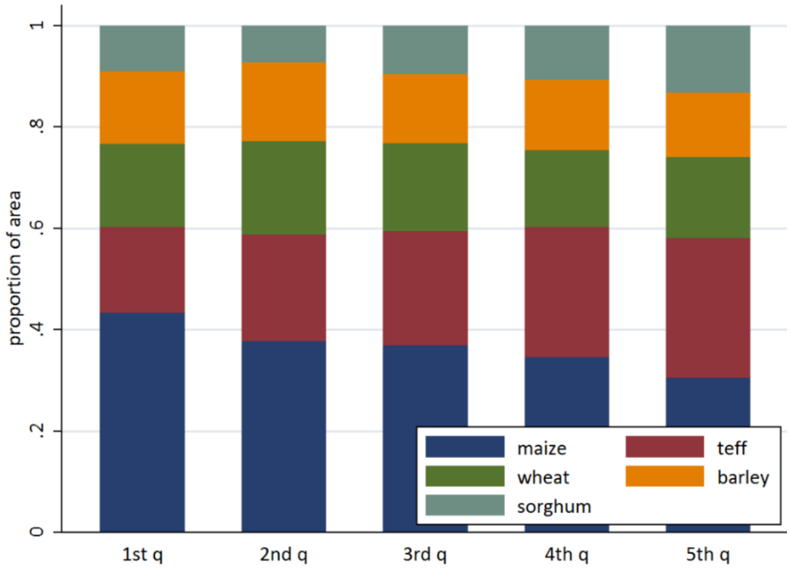
[2] This finding is in line with recent work by Brown, Ravallion, and Van De Walle (2017) who document that a surprisingly large fraction of the under-nourished children in sub-Saharan Africa reside in wealthier households.

Figure 4: Area allocation of different food crop groups, by land ownership quintile



Source: Authors' calculation from Feed the Future 2015 midline survey data.

Figure 5: Area allocation of different cereals, by land ownership quintile



Source: Authors' calculation from Feed the Future 2015 midline survey data.

5.3. Intensification

Another reason for the observed disconnect between land size and food security outcomes could be that that yields (production per area) are considerably higher on smaller farms, as is often found in the literature (e.g., Barrett, Bellemare, and Hou 2010).[3] Table 9 shows that for all cereals, except wheat, households with smaller farms have higher yields. The story is mixed for other non-cereal crops. Still, these yield differences are not large enough to explain the small difference in calorie production relative to farm size observed in Table 5.

[3] There is an intense debate in the literature whether this inverse relationship between productivity and land size is an artefact of systematic measurement error, either in land size or crop output (e.g. Carletto, Savastano, and Zezza 2013, Desiere 2016, Gourlay, Kilic, and Lobell) or driven by other factors (e.g. Bevis and Barrett 2017, Barrett, Bellemare, and Hou 2010).

Table 9: Yields by crop and land ownership quintile, quintals per hectare

Land quintile:	1st	2nd	3rd	4th	5th
Cereals:					
Teff	7.8	7.6	7.6	7.0	6.5
	(4.4)	(4.4)	(4.2)	(3.8)	(3.9)
Barley	13.3	13.2	12.7	11.9	12.1
	(6.9)	(7.3)	(6.4)	(6.3)	(6.3)
Wheat	13.7	13.9	14.4	13.5	14.0
	(7.5)	(8.3)	(7.9)	(7.7)	(8.1)
Maize	16.9	15.6	16.9	15.7	15.0
	(10.8)	(9.8)	(10.6)	(9.7)	(9.5)
Sorghum	12.5	11.6	10.0	11.3	9.1
	(8.8)	(7.8)	(6.8)	(7.7)	(6.6)
Other crops:					
Horse bean	10.1	10.1	8.8	8.8	8.6
	(6.4)	(6.5)	(5.0)	(5.6)	(5.6)
Coffee	13.6	12.4	10.7	9.4	10.8
	(9.2)	(9.6)	(8.9)	(7.5)	(6.7)
Enset	54.2	40.6	38.4	43.3	40.3
	(63.2)	(46.4)	(46.6)	(63.1)	(65.7)
Millet	9.7	10.9	10.7	9.3	9.9
	(4.6)	(6.4)	(6.1)	(5.3)	(5.9)
Potato	40.8	39.9	43.3	42.2	42.2
	(32.5)	(31.6)	(32.6)	(32.4)	(29.4)
Cowpea	8.4	7.6	6.8	7.6	7.6
	(4.3)	(4.6)	(4.0)	(4.1)	(4.6)
Niger-seed	2.9	2.1	3.3	3.1	3.1
	(2.0)	(1.3)	(2.2)	(1.8)	(1.8)
Cabbage	102.7	90.0	62.8	58.8	73.7
	(141.6)	(108.9)	(95.9)	(111.0)	(110.7)
Rice	37.8	33.8	37.2	20.0	17.9
	(12.8)	(19.3)	(24.0)	(9.2)	(9.6)

Source: Authors' calculation from Feed the Future 2015 midline survey data. Standard errors in parentheses.

We further look at investments in fertilizers and improved seeds – proxies for agricultural intensification – and explore if households with larger landholdings are more or less likely to invest in these. Table 10 shows that the likelihood that the household applies fertilizer increases with land size. Nearly 60 percent of households in the lowest land quintile uses fertilizers on their plots. This increases to 71 percent among households in the 5th land quintile. However, the opposite is true when we look at fertilizer use per hectare. Here, households with smaller landholdings use nearly three times more fertilizer per hectare than households in the 5th quintile. When we look at improved seeds, we do not see a clear trend as for three out of the five cereals, adoption rates of improved seeds are higher for larger farms, while the opposite is true for the other two. When we assess the adoption of agro-chemicals, they are mostly more intensively used by larger farm sizes – this is especially the case for herbicides, possibly because larger farms lack relatively more access to labor and herbicides are considered a substitute for weeding labor (Tamru et al. 2017).

Table 10: Adoption of fertilizers, improved seeds, and agro-chemicals, by cereal and land ownership quintile

Land quintile:	crops	1st	2nd	3rd	4th	5th
Fertilizer use, % of households	All	59.7	66.0	69.2	70.3	70.9
	Teff	51.1	46.7	45.6	40.9	42.7
	Barley	57.0	60.6	60.1	58.3	62.0
	Wheat	78.4	80.1	79.3	75.3	83.8
	Maize	49.8	53.6	53.8	50.9	49.7
	Sorghum	15.2	24.5	16.2	18.1	16.7
Fertilizer, kg/ha	All	155	92	73	62	52
	Teff	72.8	72.1	67.6	57.4	61.8
	Barley	96.6	94.5	91.5	83.4	78.0
	Wheat	148.9	152.6	143.1	124.1	139.1
	Maize	101.6	93.4	99.7	95.7	93.7
	Sorghum	17.0	31.7	18.8	20.2	16.6
Use of improved seed, %	All	32.6	37.7	42.4	42.4	43.2
	Teff	15.2	12.7	15.0	18.0	12.9
	Barley	11.9	14.3	14.8	16.6	22.7
	Wheat	25.6	30.1	33.4	30.0	30.8
	Maize	38.6	42.0	44.1	44.1	42.6
	Sorghum	9.9	11.7	11.6	11.9	6.3
Use of agro-chemicals, %	All	24.1	28.0	30.8	32.0	41.2
	Teff	26.3	21.9	23.2	17.8	23.4
	Barley	21.9	20.6	23.3	25.8	30.0
	Wheat	38.1	38.7	39.7	38.4	51.0
	Maize	3.1	3.4	4.3	2.8	3.5
	Sorghum	8.8	5.5	6.6	7.7	8.5
Use of herbicides, %	All	19.0	22.6	24.7	27.0	36.4
	Teff	25.1	20.6	21.7	17.0	22.9
	Barley	19.9	19.7	21.5	24.9	27.0
	Wheat	36.3	37.0	36.8	37.1	48.7
	Maize	2.1	1.1	2.7	1.3	2.8
	Sorghum	5.8	3.7	2.9	5.2	8.0

Source: Authors' calculation from Feed the Future 2015 midline survey data.

In Table 11 we study the use of labor and mechanized agriculture across the land quintiles. We see that households with less land use more labor per hectare and are less likely to engage in mechanized agriculture than are households with larger landholdings. However, the differences are not that large. Overall labor use per hectare is only 27 percent higher on smaller farms compared to larger ones, despite cultivated areas being almost six times as large. Differences in labor use are noted in almost all activities of the agricultural production process, including clearing, weeding and harvesting.

Table 11: Use of labor and mechanization, by land ownership quintile, person-days per hectare

Land quintile:	1st	2nd	3rd	4th	5th
All activities	102	96	89	87	80
Clearing	21	20	18	17	15
Planting	13	12	11	11	10
Weeding	38	36	34	33	30
Harvesting	30	28	26	26	25
Any mechanization, %	3.7	4.8	4.9	5.7	9.5

Source: Authors' calculation from Feed the Future 2015 midline survey data.

5.4. Non-crop and non-farm income

We now shift focus to overall income portfolios and examine the question if households with less land are able to compensate for differences in crop income through income from other sources: livestock, wage employment, own businesses, and remittances. Table 12 shows that crop income accounts for 67 percent of the total income in the case of households that own least land. This jumps to 81 percent in the second land quintile and is more than 90 percent for households with the largest landholdings. Moreover, we see that households in the first land quintile compensate for lower crop income with income from own businesses (13 percent of total income), livestock rearing (12 percent), and remittances (4.1 percent). This finding is in contrast to recent evidence from cross-country analyses (Headey and Jayne 2014).

Table 12: Income from different sources, by land ownership quintile

Land quintile:	1st	2nd	3rd	4th	5th
Total income, birr	**6,794**	**10,786**	**14,256**	**20,349**	**32,282**
Crop production, %	67	81	85	87	91
From livestock, %	12.0	8.4	8.0	8.2	6.0
Remittance income, %	4.1	3.2	2.5	1.6	0.8
Non-farm wage activities, %	1.9	1.2	0.8	0.6	0.3
Off farm wage activities, %	1.6	0.6	0.3	0.2	0.1
Own business, %	13.0	6.0	3.6	2.5	1.7

Source: Authors' calculation from Feed the Future 2015 midline survey data.

5.5. Output use and food consumption

Finally, we look at agricultural output use and food consumption. Table 13 gives an overview by land quintile of the use of calories expressed in calories per day produced. The results show that the majority of the calories produced on the farm are consumed by the household itself. In the case of the first quintile, 63 percent of production is consumed by the household itself. This compares to just below 50 percent for households in the quintile with the biggest farm sizes. These results indicate that in order to reach the same consumption levels, households from smaller farms need to rely more intensively on food purchases than larger farms, at least for their staples.

Table 13: Agricultural output use, by land ownership quintile

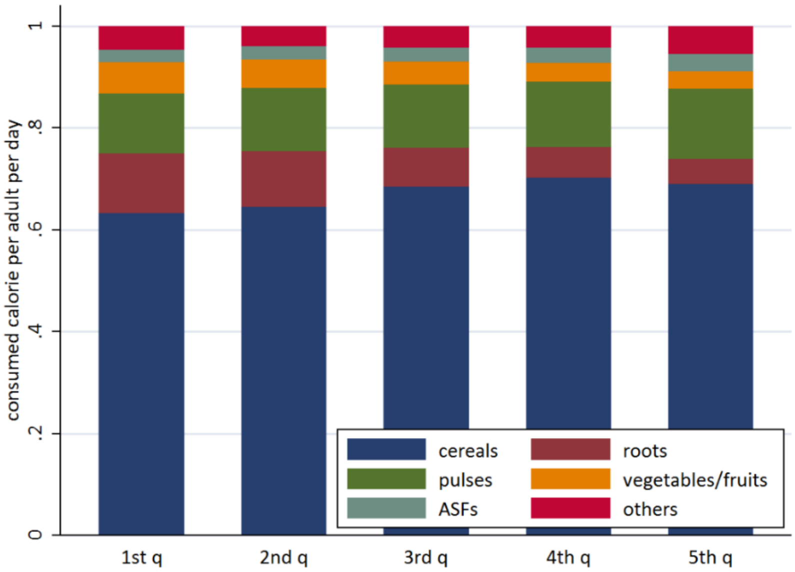
Land quintile:	1st	2nd	3rd	4th	5th
Total calorie production, kcal/day	**2,423**	**2,728**	**3,055**	**3,757**	**4,879**
Auto-consumed calorie, kcal/day	1,223	1,470	1,636	1,876	2,103
Sold calorie, kcal/day	429	591	679	916	1,336
Seed, kcal/day	88	155	182	221	358
Gift, kcal/day	40	85	33	67	62
Animal feed, kcal/day	5	8	8	12	36
Storage or loss, kcal/day	638	419	517	665	984
Auto-consumed calorie, %	62.6	62.6	60.1	55.9	49.9
Sold calorie, %	15.3	18.0	19.8	20.5	24.3
Seed, %	3.6	5.2	5.8	6.2	7.3
Gift, %	1.0	1.3	0.9	1.3	1.2
Animal feed, %	0.3	0.2	0.3	0.4	0.7
Storage or loss, %	20.8	17.9	18.9	21.9	23.9

Source: Authors' calculation from Feed the Future 2015 midline survey data.

We next look at food consumption patterns by land quintile. As shown in other research in Ethiopia (Worku et al. 2017), cereals account for the bulk of the overall sources of calories in all household types (Figure 6).

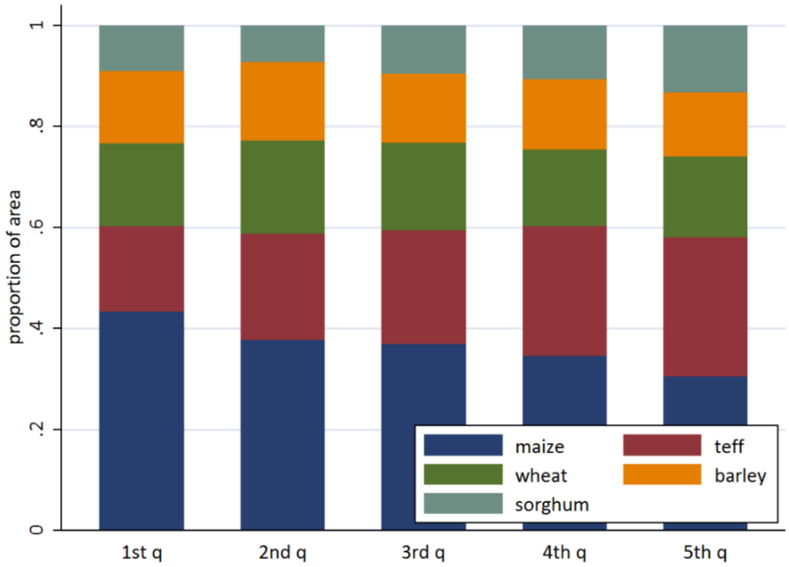
Root crop are relatively more important for the bottom land quintiles than in the top quintiles. Within cereals (Figure 7), maize is the single most important crop in terms of calories for all households. However, its importance declines as we move across the land size distribution. Teff becomes more important in the food consumption basket in the top land quintiles.

Figure 6: Sources of calories from different food groups, by land ownership quintile



Source: Authors' calculation from Feed the Future 2015 midline survey data.

Figure 7: Sources of calories from cereals, by land ownership quintile



Source: Authors' calculation from Feed the Future 2015 midline survey data.

6. CONCLUDING REMARKS

This paper studies associations between farm size, food security, and welfare. Given agricultural land constraints and the rapidly increasing rural population in Ethiopia, with 26 million more people being projected to be residing in rural Ethiopia in 2030 relative to 2016, this is a major concern for the country.

Unsurprisingly, we find that larger landholdings are associated with considerably higher crop income. However, despite these large differences in crop income, we find that there are small differences in welfare and food security. In particular, per capita food consumption levels are surprisingly similar across the land quintiles. Further analysis suggests that households with smaller landholdings compensate lower crop incomes by engaging in other income generating activities, such as livestock rearing and running non-farm businesses. They also engage in more intensified agriculture by using more labor per unit of land and by applying considerably more fertilizer per hectare than do other households. They also grow different crops and focus on bulkier, calorie-dense, and lower-valued crops. Households on smaller farms consume cheaper foods. Moreover, the smallest land ownership quintile engages actively in land rental markets and is therefore able to double its cultivated land compared to what it owns.

This study has limitations. The analysis is purely descriptive and static in nature. The associations documented here should not be interpreted as causal. In particular, we cannot be sure whether the differences across the land quintiles are driven by differences in land ownership or by other household characteristics that systematically differ between households that own different amount of land. Moreover, decreasing average land sizes may bring in dynamics that cannot be predicted using cross-sectional or short longitudinal surveys. For example, as a result of decreasing land sizes, an increasing share of the younger population may seek employment outside of agriculture. Recent evidence suggests that this might indeed be the case (Bezu and Holden 2014, Kosec et al. 2016).

Mindful of these limitations, our study suggests a number of implications to consider going forward. First, land rental markets should be stimulated as especially less land-endowed farms seem to rely substantially on these markets to obtain access to land that they are then able to cultivate more intensively. More active land rental markets could therefore contribute towards equity and higher productivity. Second, an active rural off-farm sector is important in order to allow farmers to further diversify their agricultural activities. Making sure that there is an enabling environment that allows farmers to diversify in such off-farm activities is therefore useful. Third, providing easier access to land-intensifying agricultural technologies – such as modern inputs as well as access to irrigation, allowing more intensive cultivation on the same piece of land – might be important.

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APPENDIX: REPLICATING THE SECTION 4 ANALYSIS USING THE ETHIOPIAN SOCIOECONOMIC SURVEY 2013/14

Table A1: Land distribution by land ownership quintile, Ethiopian Socioeconomic Survey 2013/14

Land quintile:	1st	2nd	3rd	4th	5th
Minimum	0.001	0.29	0.61	0.97	1.56
Mean	0.15	0.45	0.78	1.22	2.33
Median	0.16	0.45	0.77	1.20	2.08
Maximum	0.29	0.61	0.97	1.56	7.82

Source: Authors' calculation from the Ethiopian Socioeconomic Survey 2013/14 data. Observations: 2,173 households

Table A2: Total annual agricultural production by land ownership quintile, Ethiopian Socioeconomic Survey 2013/14

Land quintile:	statistic	1st	2nd	3rd	4th	5th
Total agricultural production, birr	mean	2,559	3,572	4,144	4,476	5,183
	median	1,863	2,882	3,402	4,006	4,499

Source: Authors' calculation from the Ethiopian Socioeconomic Survey 2013/14 data. Observations: 2,173 households

Table A3: Welfare indicators by land ownership quintile, Ethiopian Socioeconomic Survey 2013/14

Land quintile:	statistic	1st	2nd	3rd	4th	5th
Per adult equivalent consumption, birr	mean	4,481	6,033	5,542	5,336	5,179
	median	3,854	4,192	4,022	4,340	4,090
Per adult equivalent food consumption, birr	mean	3,616	5,151	4,637	4,412	4,108
	median	3,023	3,298	3,131	3,553	3,214
Per adult equivalent non-food consumption, birr	mean	865	882	906	924	1,071
	median	591	682	683	770	729
Non-food consumption out of total consumption, %	mean	19.3	14.6	16.3	17.3	20.7
	median	15.3	16.3	17.0	17.7	17.8
Household size, adult equivalents	mean	3.3	4.0	4.2	4.5	4.9
	median	3.2	3.7	4.0	4.5	4.9

Source: Authors' calculation from the Ethiopian Socioeconomic Survey 2013/14 data. Observations: 2,173 households
Note: all consumption values are expressed in annual terms.

Table A4: Welfare indicators by land ownership quintile – controlling for regional differences, Ethiopian Socioeconomic Survey 2013/14

	1	2	3	4	5	6	7	8
dependent variable:	(log) annual per adult equivalent consumption		(log) annual per adult equivalent food consumption		(log) annual per adult equivalent non-food consumption		non-food consumption out of total consumption	
(log) land owned (hectares)	0.034**	0.049***	0.078***	0.071***	0.022	0.041***	-0.008***	-0.005*
	(0.013)	(0.014)	(0.020)	(0.021)	(0.014)	(0.014)	(0.002)	(0.002)
household size in adult equivalent units		-0.088***		-0.046***		-0.097***		-0.006***
		(0.009)		(0.011)		(0.009)		(0.001)
Region dummies?	No	Yes	No	Yes	No	Yes	No	Yes
Observations	2,173	2,173	2,166	2,166	2,173	2,173	2,173	2,173
R^2	0.003	0.053	0.010	0.045	0.001	0.044	0.005	0.019

Source: Authors' calculation from the Ethiopian Socioeconomic Survey 2013/14 data.
Note: Robust standard errors in parentheses.

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