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Abstract

This study utilizes land registry data from the First and Second Stage Land Registration Reforms that took place in 1998 and 2016 in sampled districts and communities in Tigray region of Ethiopia. Tigray was the first region to implement low-cost land registration and certification in Ethiopia and providing household level land certificates in the names of household heads. Second Stage Land Registration and Certification (SSLRC) is scaled up since 2015 and provides households with parcel-based certificates with maps. The SSLR&C lists all holders of parcels by name and gender. We utilize the SSLR data for detailed gender-disaggregated analysis after aggregating parcel data by gender to household level and categorizing households in male- and female-headed households. Data from 11 municipalities (tabias) in four districts (woredas) are utilized. This covers 78700 parcels in the SSLR database allocated to 31500 households. Various statistical measures, including graphical tools, are used to assess the gender-disaggregated, spatial and intertemporal variation in land distribution. The comparison of First Stage Land Registry (FSLR) data with SSLR data facilitates critical assessment of the quality of the FSLR data as well as an assessment of changes in farm size distribution over the 18 years period. We find from the total sample of SSLR data, which represents an area of 30000 ha, that the female ownership share for this land is as high as 48.8% and indicates a considerably lower skewness in the distribution between men and women than we had hypothesized. The Gini-coefficient for land distribution among women is lower than that among men (0.45 versus 0.57). The share of male-headed households with no female landowners varied from 25 to 60% across communities. Male-headed households have on average 34% more land than female-headed households but this difference was reduced to less than 10% in terms of land per capita (after correcting for differences in family size between male-headed and female-headed households). There is a clear trend towards smaller farm sizes from the FSLR in 1998 to the SSLR in 2016. The share of farms below one ha varies from 0.50 to 0.90 across communities in the SSLR data.

Key words: land registry data; farm size distribution; gender-disaggregated land ownership; cumulative distribution functions; land fragmentation.

JEL codes: Q15.

1. Introduction

The importance of access to land as a primary source of livelihood in rural areas has been known since ancient times. During the modernization and industrialization of the world land was given less attention as it was seen as abundant and with low marginal value in large parts of the world. In agrarian based economies where population densities have continued to increase, land scarcity has increased and land as a source of livelihood remains crucial for large rural populations e.g. in Sub-Saharan Africa. These are also the countries with highest levels of poverty and where the majority of the poor live in rural areas (World Bank 2007). There is close correlation between land holdings and the level of poverty in such economies. A more skewed land distribution is likely to imply a more skewed wealth distribution and a larger share of households in poverty. The Sustainable Development Goals that were agreed upon in 2016 also give more emphasis to women's land rights and documenting these[1].

Data on the gender distribution of land in Africa are weak and many flawed narratives have existed on this (Doss et al. 2015). Larger and more representative and reliable surveys on the issue are starting to appear but there is still a long way to go before we have good and reliable indicators on the gender distribution of land. While there have been quite a few studies comparing land ownership of male- and female-headed households (Doss et al. 2015; Fisher and Naidoo 2016), there exist very few studies that have investigated the land ownership distribution within male-headed and female-headed households. No earlier studies in Africa have measured the share of land owned by women (Doss et al. 2015). This is therefore the first study of its kind in Africa as we investigate the documented land rights of men and women based on two land registration reforms in northern Ethiopia within a period of 18 years. The Second Stage Land Registry (SSLR) data from 2016 allows us to do a much more detailed gender disaggregated analysis, including assessing the within household share of land owned by women, such as the within male-headed and female-headed household cumulative shares of land owned by women.

Dokken (2015), using farm household survey data from northern Ethiopia, where land certificates were issued in the name of household head only, found that female-headed households have 23% smaller owned landholdings than male headed households. This study draws on household land certificate data from the first round registration for these households. In this study, we provide a more comprehensive assessment by utilizing data from complete land registry data from 11 municipalities in four districts. We are able to

[1] The Sustainable Development Goal Target 1.4. states "*By 2030, ensure that all men and women, in particular the poor and the vulnerable, have equal rights to economic resources, as well as access to basic services, ownership and control over land and other forms of property*" (World Bank and UN-Habitat 2016).

assess whether there has been a change in the degree of gender discrimination of female-headed households from the First Stage Land Registration (FSLR) in 1998 and up to the SSLR in 2016. Some fear that the lack of joint registration of husbands and wives in the FSLR may have consequences for the gender-distribution of land rights also in the SSLR.

This study is concerned with the land distribution within a densely populated agriculture-dependent country in Africa where the population growth is still high. This population growth in rural areas is also likely to substantially affect the land distribution in rural areas over the 18 years, which our land registry data cover. Our data come from the same geographical units in northern Ethiopia at two points in time, in 1998 and 2016. This facilitates an assessment of changes in farm size distribution over this time period. Our basic hypothesis is that the farm size distribution has moved from an egalitarian distribution, given the history of land redistribution in Ethiopia, towards a more in-egalitarian distribution.

Reliable gender-disaggregated data on land ownership in developing countries is scarce. Most nationally representative surveys that collect such data are based on households' stated land sizes. The quality of such collected data is poor and should be replaced by more reliable data, e.g. measured by GPS (Carletto et al. 2013). Formal land registration and titling programs, where they exist, provide more reliable information on farm sizes and parcel sizes. We may wonder, though, whether the very low-cost FSLR collected reliable parcel size and farm size data since only local tools such as rope was used for the measurement of parcels. By comparing the FSLR and SSLR data for the same communities and even households we are able to assess the reliability of the FSLR data. This is the third unique contribution of this paper. We hypothesize that FSLR farm and parcel sizes suffer from rounding errors and underestimation of farm sizes. We base the rounding error hypothesis on land being measured in the local unit *tsimdi*, the area that a pair of oxen can cultivate in the day. It is usually assumed that 1 *tsimdi*=0.25ha. Underestimation may come from fear of land redistributions in the past when households may have been able to hide their larger parcel and farm sizes to prevent their land from being redistributed to more land-poor households.

The objectives of this study are therefore for the sampled communities and districts in Tigray Region of Ethiopia; a) to make a gender-disaggregated analysis of the documented land rights in SSLR data by assessing the across-household and within-household land ownership shares of women; b) to measure inequality of land access and how this has changed from 1998 to 2016 within and across communities; and c) to assess the reliability of the FSLR data and the extent of measurement error and how this may bias land distribution measures when comparing FSLR and SSLR data.

2. Background

Ethiopia has implemented two successive rural land registration and certification reforms since the late 1990s. The first reform, First Stage Land Registration and Certification (FSLR&C) is characterized as one of the largest, fastest and most cost-effective land registration and certification reforms in Africa (Deininger et al., 2008). Though the primary cost of the first stage land registration was very low, a number of studies reported its positive impact in enhancing tenure security. This enhanced tenure security has contributed to a reduction in land-related disputes, increased investment on land, improved land productivity, and enhanced land rental market activity (Deininger et al., 2008, 2011; Holden et al., 2009, 2011a; 2011b; Bezabih et al., 2016; Gebru and Holden, 2015). Female-headed households have in particular benefitted from the improved tenure security and this made them more able to rent out their land through sharecropping contracts (Holden et al. 2011a). This has made them more food secure and has resulted in improved child nutrition (Holden and Ghebru 2013; Ghebru and Holden 2013). The First Stage Land Certificates (FSLC) were allocated to households and provided information on the parcels households possessed user rights to.

The Second Stage Land Registration and Certification (SSLR&C) aims to upgrade land registries with modern low-cost technologies and provides land holders parcel-level certificates with maps and modernize rural land administrations with computerized and map-based land registries that facilitate land use planning.

The first stage land registration and certification was a broad-scale registration that covered large number of communities and millions of plots of land within a short period of time (Deininger et al., 2008) through a participatory process with the involvement of locals in the identification and demarcation of plot boundaries, with neighbors aiding as witnesses. Bezu and Holden (2014) noted the strengths and weakness of the first stage land registration and certification. The strengths include the fact that it did not require skilled surveyors, it is a low-cost registration and certification process in terms of both resources and time required, and transparent for it involved broad participation of the locals. It had also conflict resolution system in place, which is based on existing systems in the communities, in cases of disputed plots. The demerits include that the registration was done on registry books that were hand-written, making it difficult and cumbersome to update records in the event of land inheritances, gifts or divisions due to divorce. Unique identification numbers were provided to households rather than plots and the certificate did not include maps of the farm plots. Moreover, the data is paper-based and is not easily accessible for the purpose of land administration and policy analysis (Bezu and Holden, 2014).

Based on the learning experience from the weaknesses and strengths of the FSLR&C, Ethiopia has been piloting a SSLR&C since 2005. The SSLR is based on geo-referenced registration including the geographical locations and sizes of all land in the communities, including individual plots of land, both farm plots and homesteads, as well as plots of land owned by local public utilities and religious organizations. The system uses technologies such as GPS, satellite imagery or orthography. Unlike in the FSLR&C, rural households receive parcel-level certificates with maps showing the area of the parcel rather than the household level FSLCs. The objective of the SSLR&C is to enhance tenure security and create records of land registration and certification that could be maintained and updated as well as facilitate land use planning (MOA, 2013, Bezu and Holden, 2014).

The four regions of Ethiopia (Tigray, Amhara, Oromia, and Southern Nations and Nationalities and Peoples (SNNP)) had implemented the FSLR&C. These regions have also started implementing the SSLR&C. Tigray Region in Ethiopia was the first region to implement FSLR&C in 1998. From 2014 the region started scaling up SSLR. In the SSLR parcels can have more than one owner listed in the registry and at the certificate. This therefore facilitates a deeper investigation of the distribution of holder rights within households and especially by gender as the gender of each holder is also registered.

All rural residents without other means of livelihood have a constitutional right to access land for livelihood free in Ethiopia. Due to population growth, it has become increasingly difficult to satisfy this constitutional right. Based on data from the FAOSTAT database on land use and population, it can be observed that agricultural land area per capita in rural Ethiopia had been drastically decreasing from 2.4 ha in 1961 to 0.39 ha in 2013 whereas arable land per capita had been decreasing from 0.48 ha to 0.17 ha over the same period (FAO, 2017).

Land redistributions have been used to provide land to young landless households but this created tenure insecurity on agricultural land and such land is no longer (since before the FSLR) redistributed as long as households fulfill their obligations to cultivate and take care of their land. Changing family sizes and bequeathing of land to children may therefore have led to increasing inequity of land access across households from 1998 to 2016 and increasing landlessness. The land registries allow analysis of the distribution of land among landed households.

3. Theory and hypotheses

3.1. Gender and land distribution

There is a lot of evidence of gender discrimination in statutory law as well as in the *de facto* way it is practiced (Deere and Doss, 2006). There can be various ways to strengthen the land rights of women. One of these is through better legal documentation of their rights. By introducing joint land registration and certification of husbands and wives in some regions where low-cost land registration and certification was implemented, women's land rights may have been strengthened in Ethiopia and such land registry data may potentially be used to investigate the gender distribution of land rights (Holden and Tefera 2008). Teklu (2005) provides evidence from the FSLR in a study in Amhara Region in Ethiopia, where joint certification of husbands and wives was practiced, showing that 29% of the land was registered in the name of women, 33% in the name of men, and 39% was jointly registered in the names of husbands and wives.

Doss et al. (2015) outline the different ways of measuring gender-division of land rights. The most common method has been to measure the percentage of men and women who are landowners or managers. The second most common measure has been the percentage of plots owned or managed by women/men. The third most common method has been the percentage of landowners who are women/men. The forth most common measure is the average plot area by gender. The fifth, which they think is the best measure, is the share of land (area or value) owned/operated/managed by women. They report only two studies that have assessed the share of land value owned by women, one in Ghana and one in Uganda (Doss et al. 2011; 2012), where 24% and 48%, respectively, of the land values were found to be owned by women. A study in Niger is the only study they found that measured the percentage of the land that was managed by women. It found that 7% of the land was managed by women and 93% managed by men.

To our knowledge, this is thus the first study in Africa that measures the share of land area with documented land rights that is owned by women. We used the parcel level SSLR data for this where each parcel can have a number of owners. We have left out public land and look only at land allocated to households. For parcels of land with more than one owner, we divide the area equally between the number of owners. We know the gender of all owners and can based on this calculate the share of each parcel that is owned by women. We aggregate this information to household level after having identified parcels that belong to the same household in the registry. The share of household land that is formally owned by women can then be uniquely identified. By identifying different types of households, such as male-headed and female-headed households, we can assess the within-household variation in gender distribution of land for each of these household types.

Furthermore, we can assess how equitable the land distribution is among women and among men across households within larger geographical units such as communities (*tabias*) or districts (*woredas*) and we can compare these distributions with the overall equity of distribution across households.

Based on the historical dominance of men in management and control over land in Ethiopia where land typically has been inherited by sons from their fathers, while women have obtained access to land through marriage and moving into the home and village of their husband, our first hypothesis is;

a) Most land remains owned by men after SSLR.

This may particularly be the case in Tigray Region where we have carried out this study as the FSLR in this region only allocated the FSLCs in the names of household heads. Our second hypothesis is therefore;

b) A large share of land owned by male-headed married households is in the name of husbands only.

Based on the study by Dokken (2015) we propose the following hypothesis;

c) Female-headed households are more land-poor than male-headed households and this remains the case after correcting for households size differences (assuming that female-headed households on average are smaller than male-headed households).

It is possible that in some communities and some households the men are more open about sharing of land with their wives. One implication of this may be that (hypothesis c);

d) The land owned by women across households and communities shows a more skewed distribution than that among men, where distribution still remains more equitable.

We use Gini-coefficients for land distribution and cumulative density graphs to assess this.

3.2. Comparing farm sizes under FSLR versus SSLR

In theory we expect that population growth from 1998 to 2016 has resulted in shrinking farm sizes by farms being split among the children when the land is transferred to the next generation. Such transfers may take place before the parents die, e.g. upon marriage of the children, or after their death. Widows may take over the land of their dead husbands or the children may take over the land at that time. We do not expect that many existing households in 1998 have received much additional land through redistribution after 1998. However, new households may have been established after 1998 that do not have access to land from their parents and these may have been allocated some land from the communities. Such allocations are expected to be very small. Overall, we hypothesize the following changes from 1998 to 2016:

e) Average farm size is reduced

f) The farm size distribution has become more skewed as new owners have smaller farm sizes than old owners still keeping their land

g) Population growth has contributed to land fragmentation

h) Measurement error in measuring parcel and farm sizes in 1998 (only local tools such as rope were used to measure parcels at that time) caused underestimated and unreliable farm size estimates at that time.

A reason for underestimation in 1998 may have been the tenure insecurity because of the history of land redistribution. This caused households with more land than others in their community to fear that some of their land to be taken and redistributed to more land-poor households. A response to this fear may have been to pretend that their farm size and parcel sizes are smaller than they really are. This may have created a downward bias in estimated parcel and farm sizes.

4. Data and methods

4.1. Data description and organization

We have established a good working relationship with the Federal and Regional Land Administrations in Ethiopia, which provide us access to the land registry data. We have sampled the following *woredas* (districts) with one to four *tabias* (municipalities) to represent the highlands of Tigray where smallholder agriculture dominates: Raya Azebo (3 *tabias*), Degua Tembien (3 *tabias*), Seharti Samre (4 *tabias*), and Kilite Awlalo (1 *tabia*). These *woredas* and *tabias* capture important variation in agro-ecology, market access, and population density and irrigation access in the highlands of the region. We obtained access to the FSLR and SSLR data of the 11 *tabias* from the four districts' Land Administration Offices.

By utilizing the full registry, we get exact measures of local land distribution to the extent that there are minimal errors in the registry data. The FSLR data for the selected *woredas* and *tabias* were available only in hard copies on the land registry books at the *woreda* Land Administration Offices. We computerized this information into Excel files by preparing a template containing all the information available on the land registry books.

The second challenge was to map parcels and their owners into households within communities. The data had to be sorted by the names of the owners and into household types (male-headed and female-headed households) based on gender of owners. The names of owners were also used to match households in the FSLR and the SSLR data. This matched sample was also used to compare the reliability of FSLR data with that of the SSLR data. It was assumed that such old household heads which occurred in the 1998 registry as well as in the 2016 registry data had fairly stable farm sizes although they may have bequeathed some land during the period. In a country where land sales are illegal and land redistributions should essentially have stopped after 1998, it is likely that a change and particularly an increase in the farm size from FSLR to SSLR is likely to be due to an under-reporting of parcel and farm sizes in the FSLR data. The FSLR parcels were measured with ropes and the recent history with land redistributions from the relatively land-rich to the land-poor may have created incentives to under-report parcel and farm sizes. Our analysis facilitates an assessment of such a tendency as well as the general accuracy of the parcel size estimates. We also used a household survey sample as an extra test of this accuracy and potential measurement error problem.

There have been changes in the administrative borders of many *tabias* in the period between 1998 and 2016. Appendix 2 contains maps of the *tabia* borders in 2007 and 2013 where there have been changes in *tabia* borders. We find that three *tabias* only out of the 11 have had stable borders in the period. These three therefore lend themselves to a more accurate assessment of changes in registered land area, and farm size distribution, including by gender of household head, and parcel size distribution (fragmentation in ownership and parcel sizes).

To assess changes in population we rely on family size data from the land registries. It turned out that family size data were not collected in all communities or they counted the number of owners only and not their remaining family members. This also reduced the sample size that was suitable for such analysis. The family size data by *tabia* and completeness of sample are presented in appendix tables A3 and A4.

4.2. Methods

The female owned share of land is calculated for each parcel based on the number of female owners over total owners for each parcel times the parcel size. We assumed that each owner has an equal share of a jointly owned parcel independently of whose name is stated as the first name on the parcel-level land certificate. Female owned land within a household is then the aggregated shares of female owned land across parcels within the household. Further aggregation of female and male owned land to community, district and total sample is done to obtain the total shares of female and male owned land. In order to assess the distribution of female and male owned land across households within communities, districts and the total sample, Gini-coefficients were calculated together with mean and median land sizes. Similarly, farm size distributions across female-headed and male-headed households were assessed using mean and median sized and Gini-distributions. The farm size distributions were also illustrated with cumulative density functions (CDFs). Such functions were also used to assess the variation in farm size distributions across districts and communities as well as to assess the variation in women's shares of owned land within households. This included the variation in the gender distribution within male-headed and female-headed households as well as the variation in the gender distribution of land within male-headed households across communities.

Next, we compared farm size distributions in the FSLR versus the SSLR data to assess changes over time while also assessing the extent of measurement error in the FSLR data. By matching households by names in the FSLR and SSLR data from the same communities, we identified old households that were likely to have had stable farm sizes over the period. By also utilizing an additional sample of surveyed farms with FSLCs combined with carefully measured plot sizes, we were able to further scrutinize the reliability of the FSLR parcel and farm sizes. This gave then a better basis also for assessing the extent of land fragmentation and shrinking of farm sizes over the 18 years period from FSLR to SSLR took place. In the CDFs of farm size distributions, we compared how the shares of farms less than one ha had changed over time and varied across communities as a simple indicator in addition to the mean and median farm sizes.

5. Results and Discussion

5.1. Gendered Land Distribution

We first make an overall assessment of distribution of land by gender for the total sample of land registry data from the SSLR. Individual ownership by gender has been aggregated from the parcel level and up to household, *tabia*, *woreda* and total sample. Table *1* is based on the SSLR data at parcel level from 11 *tabias* in four *woredas* in Tigray and includes all private registered land in these communities, including agricultural and non-agricultural land. The total sample of close to 78700 parcels represents an area of 30000 ha. The female ownership share for this land is as high as 48.8% and indicates considerably less skewness in the distribution between men and women than we had imagined. We see the female share even is 54.5% in one *tabia* in one *woreda,* while there is little variation in this share across the other *woredas*. This evidence seems therefore to lend little support for our first two hypotheses (a and b).

Table 1. SSLR Parcel based land registry data gender disaggregated: Total land of hhs.

Woreda	Total area in ha	Female land ha	Male land ha	Female share	Parcel number	Number of tabias
Raya Azebo	11232	5475	5758	0.487	18234	3
Degua Temben	6165	2903	3262	0.471	24384	3
Seharti Samire	11093	5426	5666	0.489	28985	4
Kilite Awlalo	1512	824	688	0.545	7084	1
Total	30002	14628	15375	0.488	78687	11

Source: Tigray Land Registry data from District Land Administrations. Total land includes agricultural and non-agricultural land.

In Table *2* the parcel level data have been aggregated up to household level after parcels have been matched into households based on the names of the holders. This was done after non-agricultural land had been separated out[2]. This resulted in the identification of 31150 households with an average farm size of 0.9 ha against a median farm size of 0.63 ha and with little variation in these sizes across *woredas*. Gini-coefficients are computed for the total sample of farms, for female-owned land across households, and for male-owned land across households. We see that the Gini for female owners is 0.45, indicating a less skewed distribution than for total farm size and among male owners across farms. This pattern of relative skewness being higher among men than among women is consistent across *woredas*. This implies that we can also reject hypothesis d) that land is distributed in a more in-egalitarian way among women than among men. We find firm evidence of the opposite.

Table 2. SSLR data aggregated to farm level: Farm size and farm size distribution by district

Woreda	Average farm size	Median farm size	N	Gini-coefficients		
				Hh farm size	Female hh land	Male hh land
Raya Azebo	0.906	0.697	11658	0.439	0.385	0.526
Degua Temben	0.791	0.550	7206	0.497	0.459	0.572
Seharti Samire	0.978	0.575	10558	0.548	0.507	0.606
Kilite Awlalo	0.776	0.630	1728	0.481	0.375	0.545
Average/Total N	0.897	0.625	31150	0.497	0.451	0.570

Source: Tigray Land Registry data from District Land Administrations. Only agricultural land included.

In Table *3* the land has been split between male-headed and female-headed households based on our household categorization method, utilizing names, gender and household size information for parcel-owners from the land registries. We compare farm size for the two types of households as well as farm size per capita for them. We expect household sizes to be smaller on average for female-headed households than for male-headed households. Our hypothesis was that female-headed households have less land than male-headed households, even when it comes to land per capita (Dokken 2015). We see that this is the case as female-headed households have a farm size that is about 34% lower than that of male-headed households and this can be compared with the 23% that Dokken (2015) found in her survey study from the same region. We see, however, also that after we have corrected for family size the difference is down to less than 10% in the favor of male-headed households. Still, this implies that female-headed households are more land-poor than male-headed households on average. This implies that we cannot reject our hypothesis c).

[2] For parcels we know are for non-agricultural use based on the registry data.

When it comes to how inequitable the land distribution is among male-headed households and among female-headed households we see that, like for the female owned versus male-owned land across households that the Gini is higher (0.50) among male-headed than among female-headed households (0.44). After correcting for family size, we find the Ginis to be higher for both male- and female-headed households, both being about 0.57.

Table 3. Comparing farm size and land per capita for male-headed versus female-headed households based on SSLR data for full sample/sample share with family size data

Statistic	Farm size			Agricultural Land per capita		
	Male-headed	Female-headed	Total	Male-headed	Female-headed	Total
Mean	1.002	0.664	0.897	0.282	0.261	0.276
Median	0.690	0.532	0.625	0.162	0.147	0.157
St. error	0.007	0.006	0.005	0.003	0.004	0.003
Gini-coeff.	0.502	0.436	0.497	0.572	0.569	0.572
N	21481	9669	31150	15567	6867	22434

Source: Tigray Land Registry data from District Land Administrations.

To get a better visual perspective of the land distribution of 21481 male- and 9669 female-headed household farms, we present their cumulative distributions in Figure *1*. We see that there are very few farms that are more than 5 ha. More than 80% of the farms with female heads are below one ha while more than 60% of the farms with male heads are below one ha. The graph indicates that about 10% of the households in the land registry have no farmland (slightly more male-headed than female-headed households have no farmland).

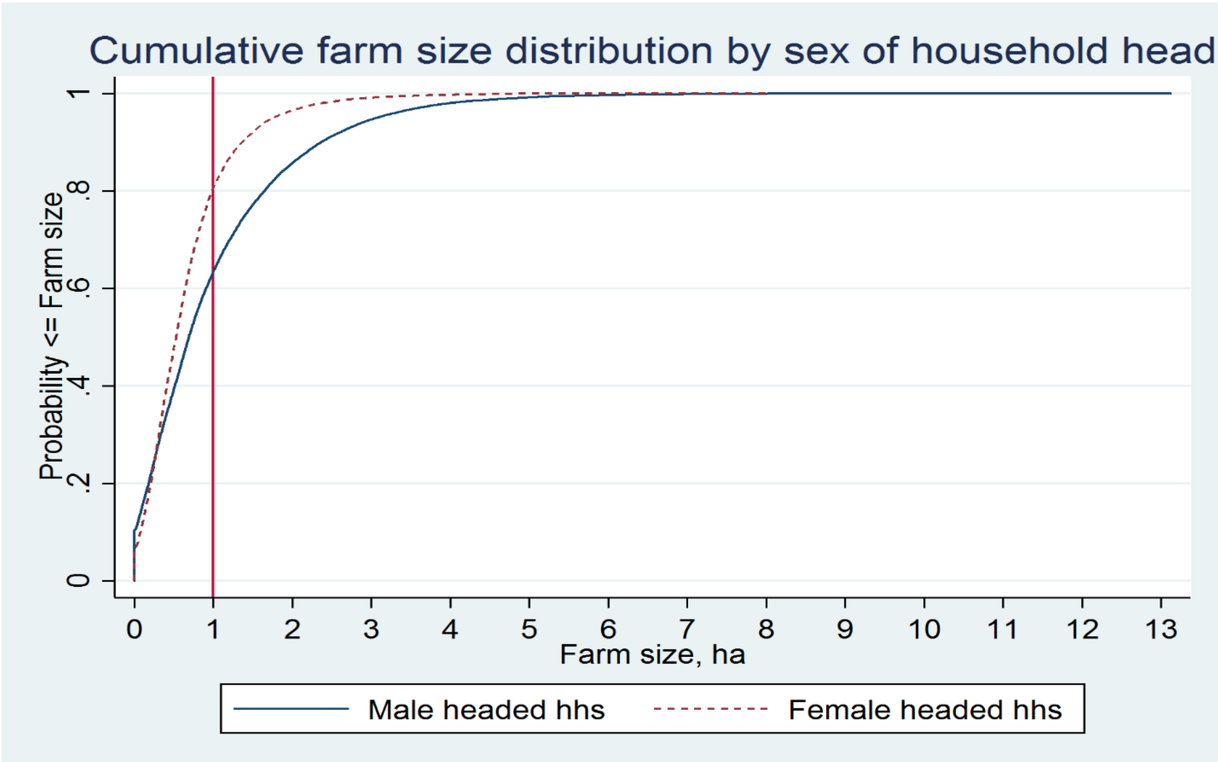

Figure 1. Farm size distribution of male and female-headed households in SSLR, full sample (31150 farms).

To get a better idea about the variation in farm size distributions across communities, community-level cumulative farm size distributions are shown in Figure *2*. We see that this variation is somewhat larger than the difference between male and female-headed households in the total sample. The share of landless registered households (that have some non-agricultural land that is registered) varies from zero to above 20% across *tabias*. All communities have more than 50% of their households with farm sizes below one ha. The two most land-poor communities have just above 80% of the households with farms less than one ha.

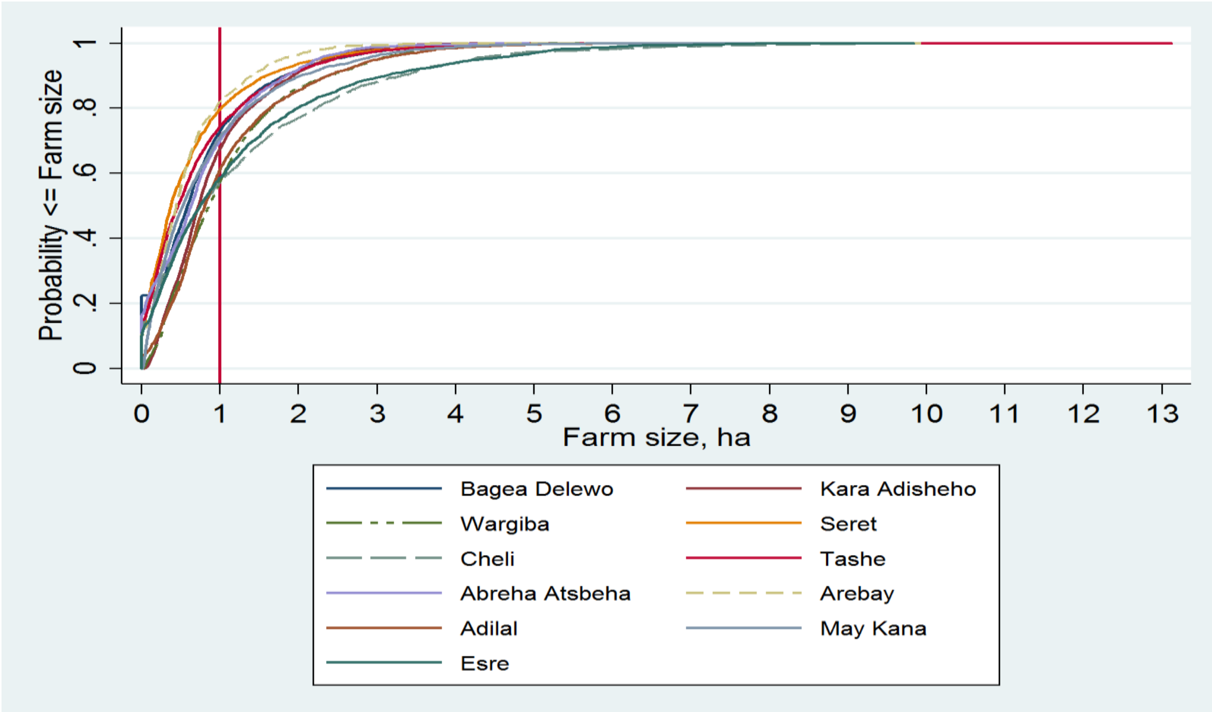

Figure 2. Farm size distribution by *tabia* in SSLR, 2016.

Next, we assess the cumulative within-household variation in share of total land that is owned by females, giving equal weight to each of the 31150 households in the total sample (Figure *3*). Figure *3* shows that about 30% of the households have land purely owned by males. Similarly, we see that about 25% of the farms have land purely owned by females. About 13% of the farms have a female share between zero and 50% and about 28% have a 50-50 share between the genders, while only about 4% have a female share between 50 and 100%.

Figures 4a and 4b show the cumulative within-household variation (cumulative density function – CDF) in share of land owned by females where total private land is divided in non-agricultural and agricultural land. Figure *4*a shows that about 60% of non-agricultural land is split 50-50, 20% is split 0:100 and the remaining 20% 100:0 between women and men, indicating no overall gender bias among those having non-agricultural land. In Figure *4*b we see that 50-50 split is less common for agricultural land than for non-agricultural land (about 25%). It is more common with pure male ownership (33%) or pure female ownership (30%), but also more common to have deviations from the corner solutions and the 50-50 split.

In Figure *5* and 5b we investigate the variations in these patterns of within-household distributions across districts and communities. We see there is no big variation across districts but somewhat stronger variations across communities. The share of females with no ownership varies from 20 to 40% across communities while the share of males with no ownership varies from 20 to 35%. The share with 50-50 split varies from 20 to close to 50%.

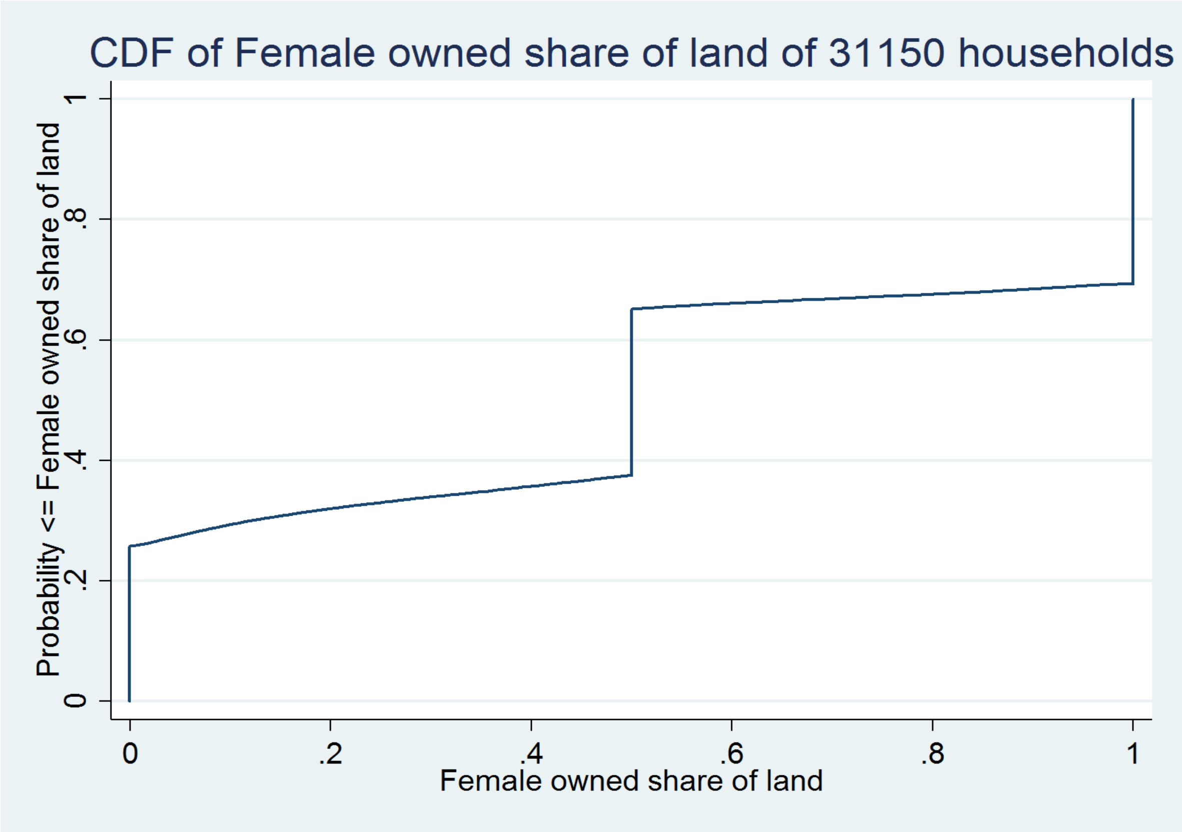

Figure 3. Cumulative Distribution Function (CDF) for females' owned share of farms based on SSLR data from 31150 farms across four districts in Tigray

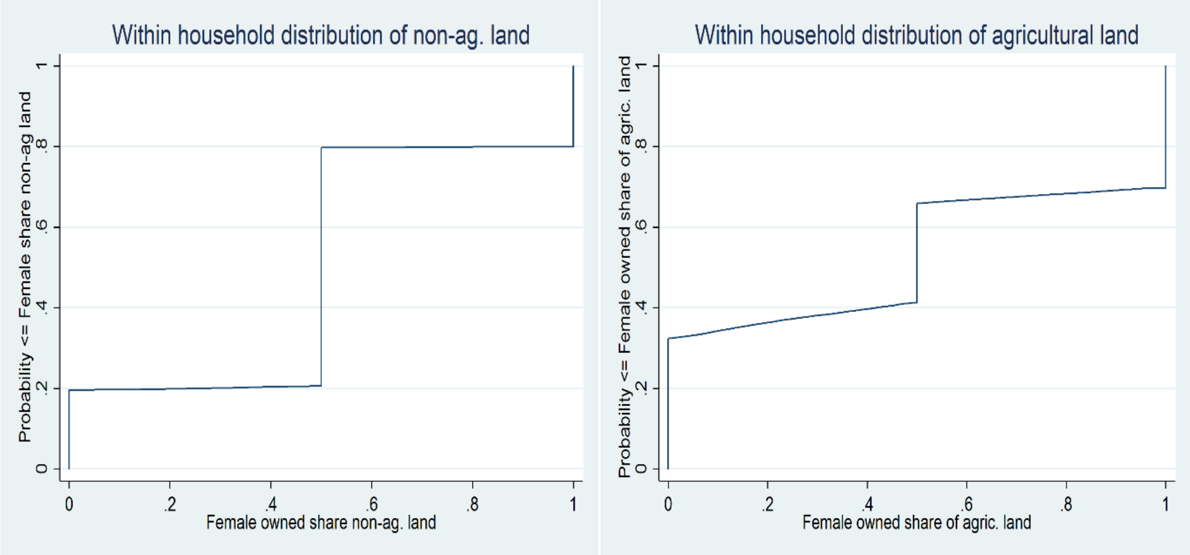

Figure 4a and 4b. CDF for female owned share of non-agricultural and agricultural land.

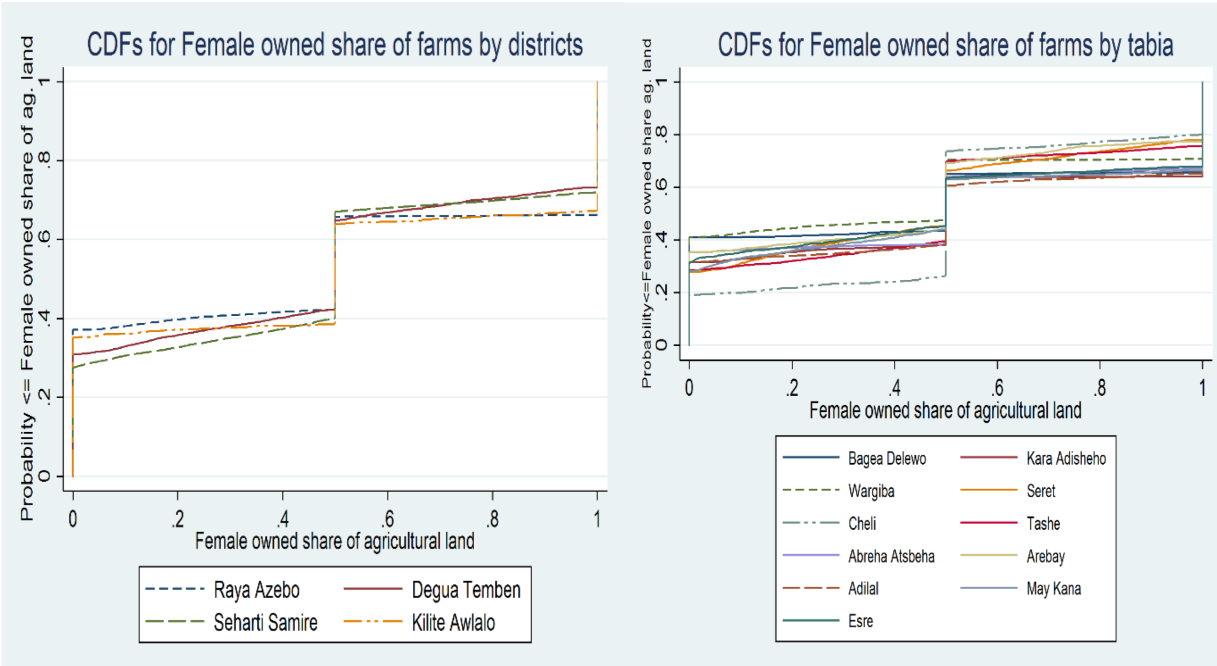

Figure 5a and 5b. Cumulative Distribution Functions for females' owned share of farms based on SSLR by woreda (district) and by *tabia* (municipality).

Next, we investigate the gender distribution of land within male-headed and female-headed households (see Figure 6). The figure shows that close to 45% of male-headed households have zero female land ownership while close to 35% have 50-50 sharing of land among the genders. Close to 15% have a female share between zero and 50%, and about 5% have a female share between 50 and 100%. For female-headed households the female share is 100% for more than 90% of the households. We should remember that male-headed households consists of married couples as well as single male households.

Figure 7 shows the variation in gender distribution of land within male-headed households across the 11 *tabias*. We see that the share with zero female ownership varies from 25 to about 60% and the share of households with 50-50 split also varies from about 25 to 60%. Of the remaining 15%, most have between zero and 50% shares.

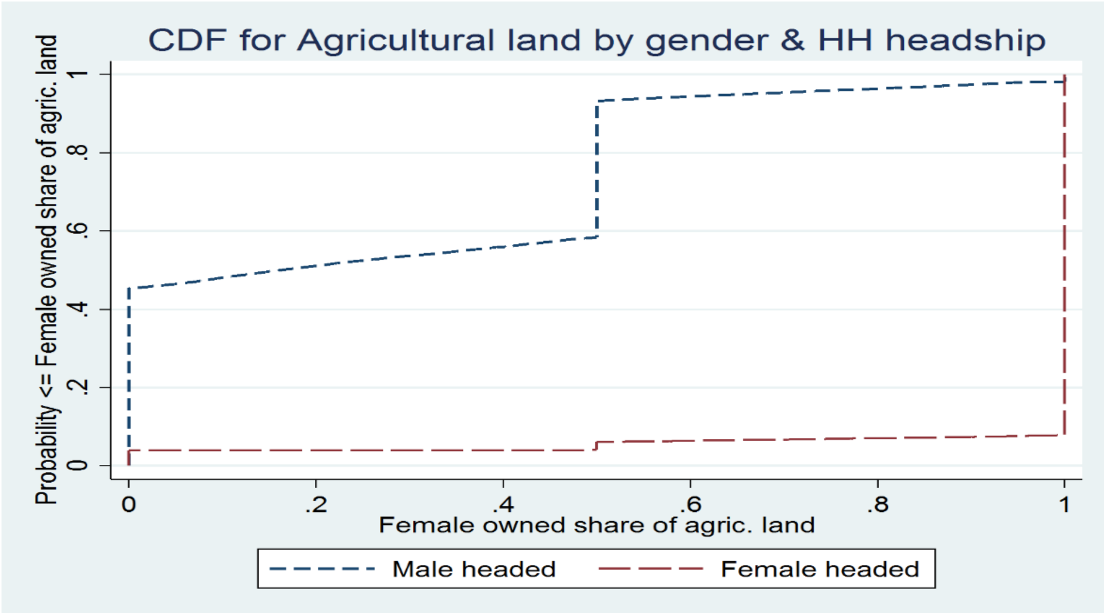

Figure 6. Gender distribution of agricultural land within male-headed and female-headed households, full sample

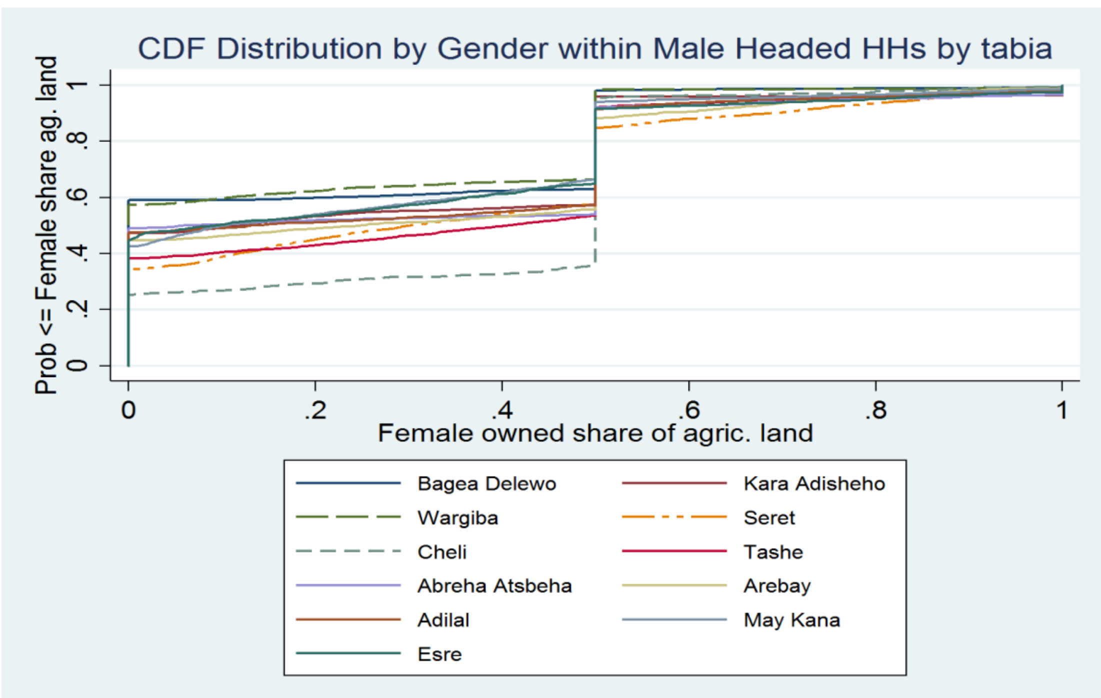

Figure 7. Within Male Headed HH gender ownership distribution of agricultural land by *tabia*.

5.2. Changes from 1998 (FSLR) to 2016 (SSLR)

We will assess the changes in farm sizes from 1998 to 2016 and test our hypotheses presented in part two of the paper. Table *4* presents the farm size distribution in the total sample of communities, the matched (old households) and unmatched samples. The unmatched sample contains new households that are new since 1998 but may also be new due to changes in community or district borders. The total number of farms has increased from about 12500 in 1998 to about 31150 in 2016, indicating possibly a large population increase. The average farm size in the total sample has been reduced from 1.15 to 0.95 ha. These figures are in line with our hypotheses e) and g) which cannot be rejected. This change in farm size is just above one percent reduction per year during this 18 years period.

Measurement errors in parcel and farm sizes and changes in community and district borders may bias these basic findings. The extent of this problem can also be observed from the matched sample in Table *4*. We expect farm sizes to slightly have been reduced for the matched sample (old households) due to some bequeathing of land to children. However, we see that the average farm size for this sample has increased from 1.18 to 1.39 ha from 1998 to 2016, contrary to our expectations and we believe measurement errors in parcel sizes and farm sizes are the main reasons for this otherwise unexpected increase. A 20% increase in the average farm size for the matched sample may be due to a 20% underestimation of farm sizes on average in 1998. The difference in median farm sizes is only about eight percent so the extent of measurement error may vary across the distribution. In fact, we see a reduction in the Gini for this matched sample from FSLR to SSLR. This may imply that measurement error has contributed to an upward bias in the Ginis for 1998. However, we cannot be sure of this, as we do not know the actual changes in farm sizes for the matched sample in this period.

Table 4. Farm size distribution in matched sample (old households), unmatched sample (new households) and total sample

Land Certification Stage	mean	p50	se(mean)	Gini	max	N
Matched sample						
FSLR	1.18	1.00	0.01	0.422	12.75	6632
SSLR	1.39	1.08	0.01	0.386	16.51	6632
Unmatched sample						
FSLR	1.11	0.85	0.01	0.364	7.88	5850
SSLR	0.82	0.56	0.01	0.512	13.23	24346
Total sample						
FSLR	1.15	0.88	0.01	0.377	12.75	12532
SSLR	0.95	0.65	0.01	0.503	16.51	31157

Source: GoE Land Registry Data with own calculations.

Our hypothesis f) that the farm size distribution has become more skewed from FSLR to SSLR cannot be rejected. For the total sample, the Gini has increased from 0.38 to 0.50. The change in borders for many of the communities implies that this comparison is not "clean".

gives the disaggregated Ginis for each community in the FSLR and SSLR data, together with mean and median farm sizes.

Table 5. Farm size distributions in FSLR and SSLR, by *tabia*

Tabia	FSLR				SSLR			
	mean	p50	Gini	N	mean	p50	Gini	N
Bagea Delewo	1.114	0.750	0.314	1283	0.931	0.660	0.399	4324
Kara Adisheho	1.325	1.125	0.337	2673	0.912	0.725	0.483	4623
Wargiba	1.599	1.375	0.367	1584	1.155	0.892	0.557	2710
Seret	1.264	1.063	0.356	932	0.470	0.350	0.471	2918
Cheli	0.824	0.625	0.281	723	1.524	0.962	0.535	1815
Tashe	0.703	0.625	0.28	1523	0.824	0.529	0.47	3347
Abreha Atsbeha	0.728	0.688	0.304	888	0.875	0.681	0.532	1728
Arebay	1.165	1.000	0.495	656	0.667	0.470	0.538	1686
Adilal	1.176	1.000	0.399	909	1.143	0.850	0.436	2610
May Kana	0.934	0.869	0.374	1010	0.839	0.526	0.492	2803
Esre	1.701	1.500	0.312	351	1.240	0.751	0.431	2593

Source: GoE Land Registry Data, own calculations.

shows that the average and median farm sizes have been reduced in 10 out of 11 sites over the period. The Ginis have increased in all communities with the Ginis in the range 0.28-0.50 during FSLR to the range 0.40-0.56 during SSLR. If we inspect the three *tabias* that have not had any change in their borders in this period (Kara Adishebo, Wargiba and Abreha Atsbeha), we see that the Ginis for farm sizes have increased from 0.30-0.37 to 0.48-0.56. This is strong evidence in favor of hypothesis f).

To get a better picture of potential measurement error in FSLR data, we use the matched data for three of the *tabias* where there has been no change in borders in the period from FSLR to SSLR (Figures 12-14). As an additional test we used own household and parcel survey data where we have collected data from housholds' FSLCs and measured the same parcels with measurement tape for a sample of 780 parcels in 16 communities. Table *6* and Figure *8* show the correspondence between FSLR measured and tape measured parcel sizes in this sample.

Table *6* shows that tape measured parcel sizes were on average about 16% larger than the FSLC measures. Measurement errors were substantial and the extent of bias varied across sites. “Rounding errors” were common in FSLR as parcel sizes were usually given in whole *tsimdi*[3] units. Figure *8* illustrates the concentration of FSLC parcel sizes at whole *tsimdi* units. We cannot therefore reject hypothesis h). Both rounding errors and downward bias in parcel sizes are evident in the FSLR data.

Table 6**.** Assessment of reliability of parcel sizes in FSLR&Cs

Stats	FSLC size	Measured with tape (M)	Difference (M-FSLC)
Mean size in *tsimdi*	1.050	1.220	0.169
Standard deviation	0.926	1.244	0.911
Standard error (mean)	0.033	0.045	0.033
N	780	780	780

Source: NMBU-MU household survey 2006. Areas measured in *tsimdi*, 1 *tsimdi*=0.25 ha.

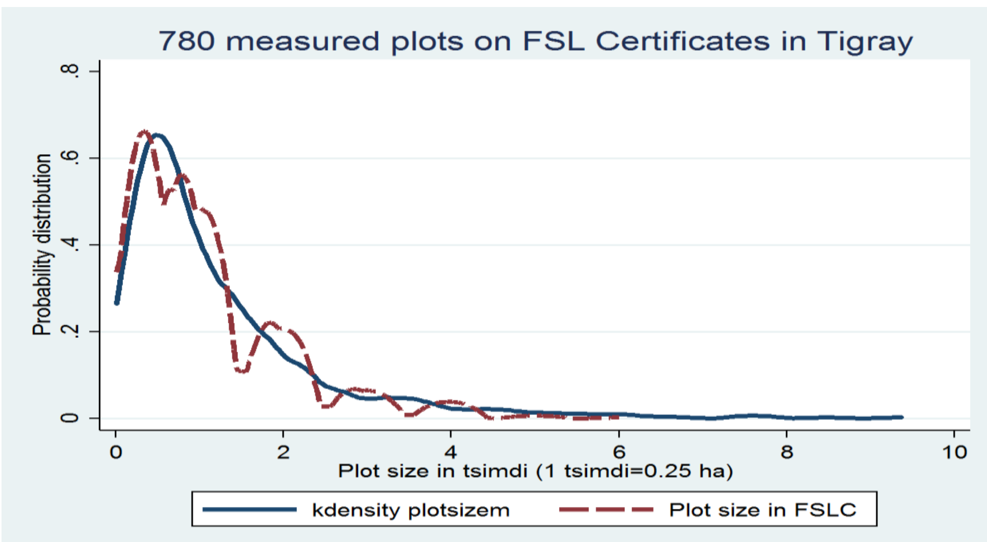

Figure 8. Kernel density graphs (probability distributions) for FSL Certificate parcel sizes versus tape-measured parcel sizes.

Figures 9 and 10 show the farm size distributions across all *tabias* during FSLR (Table 9) and SSLR (Table 10). By comparing these figures, it is not so obvious that farm sizes have reduced in the period. Figure *10*a and 10b a) and b) demonstrates “step-wise” farm size increases and this is due to the “rounding errors” (parcel and farm sizes typically measured in whole *tsimdi* units) in the FSLR data.

[3] One *tsimdi* is the area that a pair of oxen can cultivate in a day, and is usually about 0.25 ha (our assumed conversion factor).

By comparing matched (old) households that were present both during FSLR and SSLR, with the total sample, we can get a possible correction for measurement error in FSLR. Moreover, we can also assess the evolution towards smaller farm sizes by comparing old (matched) households for which we do not expect farm sizes to have changed much, to that of a full sample in SSLR possibly containing a larger share of smaller farms.

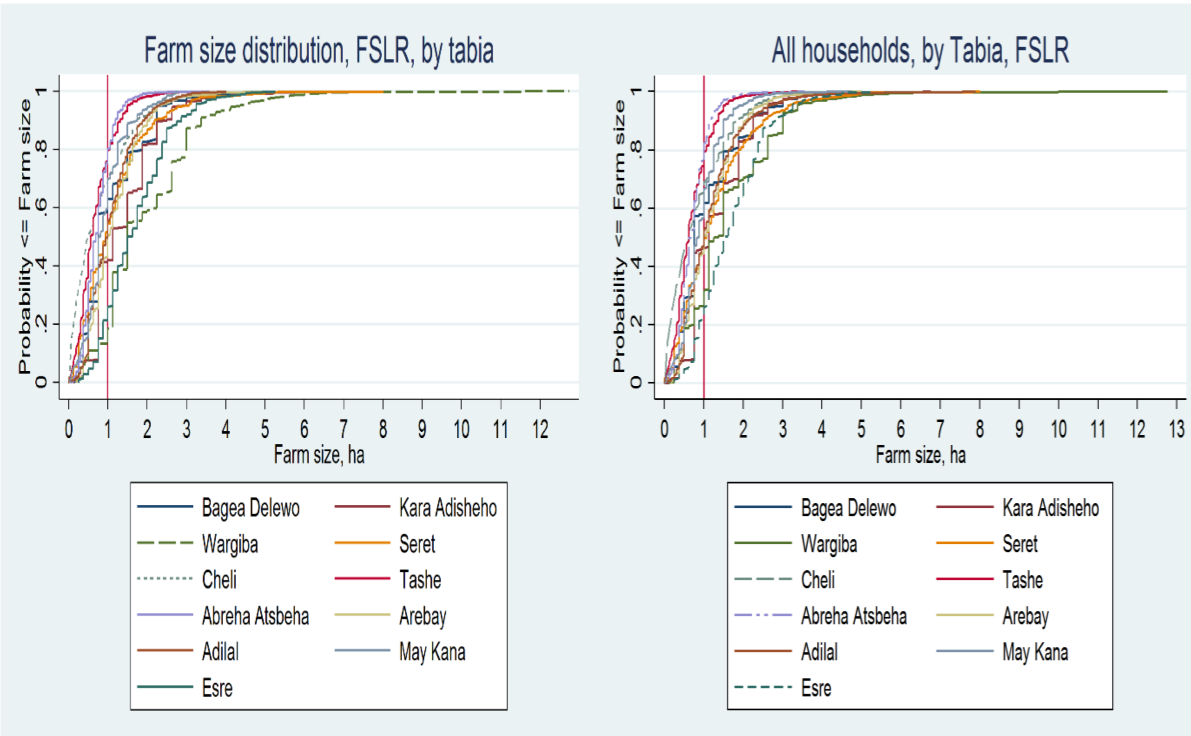

Figure 9a and 9b. Farm size distribution by *tabia*, matched sample (old households) versus all households, FSLR.

Figure 9a and 9b compare matched (old) households with the total sample in FSLR and shows that the matched sample at that time was quite representative. When the same matched sample is compared to the total sample in SSLR (Figure 10a versus 10b), we see a clear trend towards smaller farms. By assessing the one ha reference line we see that community share of farms below one ha is in the range 0.20-0.70 for the old (matched) farms while it has increased to the range 0.50-0.90 in the total sample. This shows a strong trend towards smaller farms after controlling for measurement error in the FSLR data (assuming that the old (matched) households have not had any big changes in their farm sizes.

We scrutinize this assumption further by comparing the farm size distribution of the matched (old) households in the FSLR and SSLR data. Figure 11a and 11b compares the matched (old) households with the total sample for all 11 *tabias*. The 11a graph seems to indicate that farm sizes for the matched households have increased from FSLR to SSLR. We believe this difference is due to measurement error in the FSLR data. We think this bias causes a too small difference between the curves in the 11b graph.

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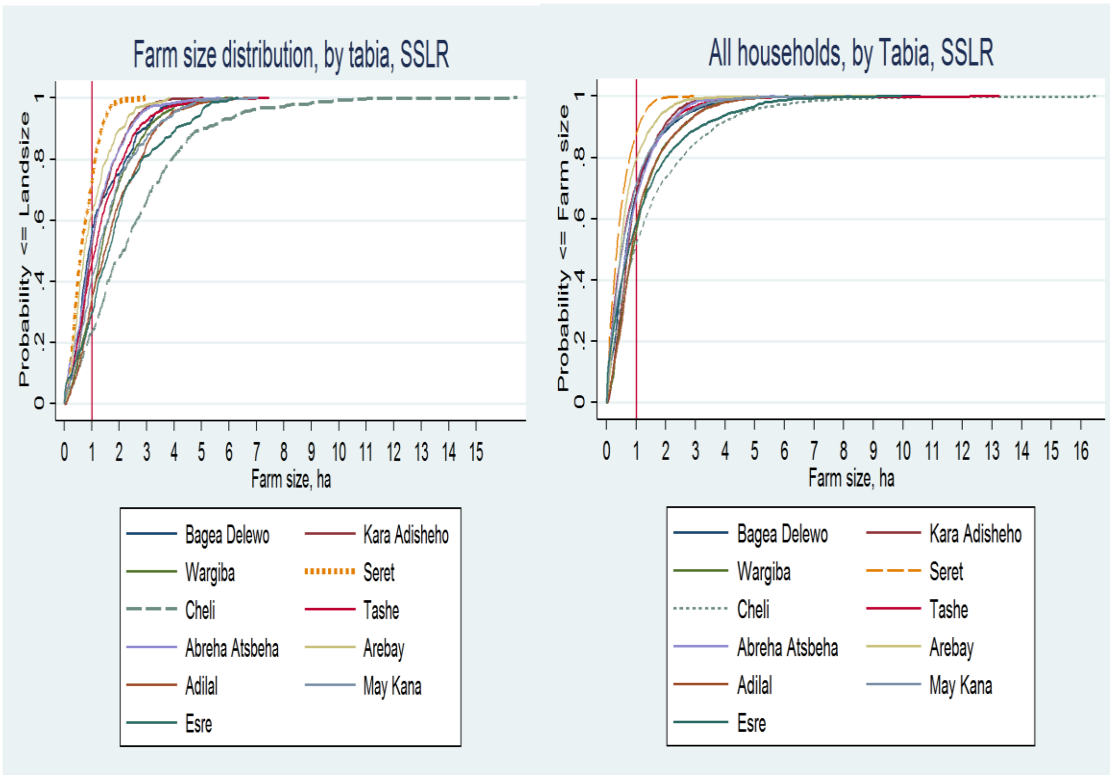

Figure 10a and 10b. Farm size distribution, matched sample (old households) versus all households, by *tabia*, SSLR.

We make a further inspection of possible size and direction of the measurement error in FSLR data by assessing the farm size distribution of matched (old) households in three communities that to our knowledge have not had any changes in their borders during the period from FSLR to SSLR.

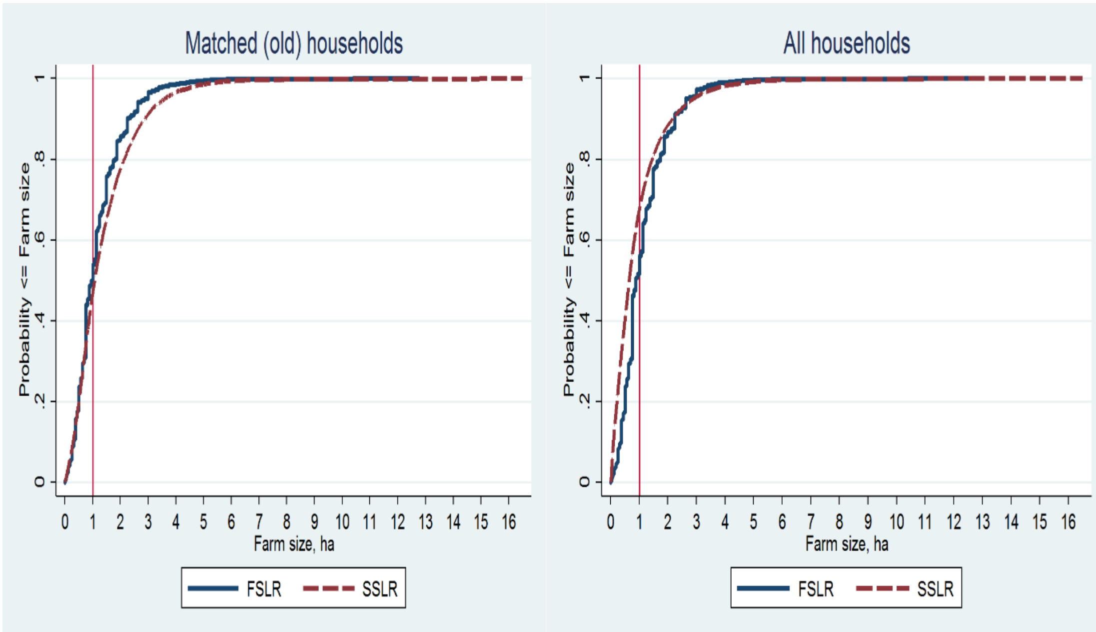

Figure 11a and 11b. Farm size distribution during FSLR versus SSLR for the matched (old) household sample.

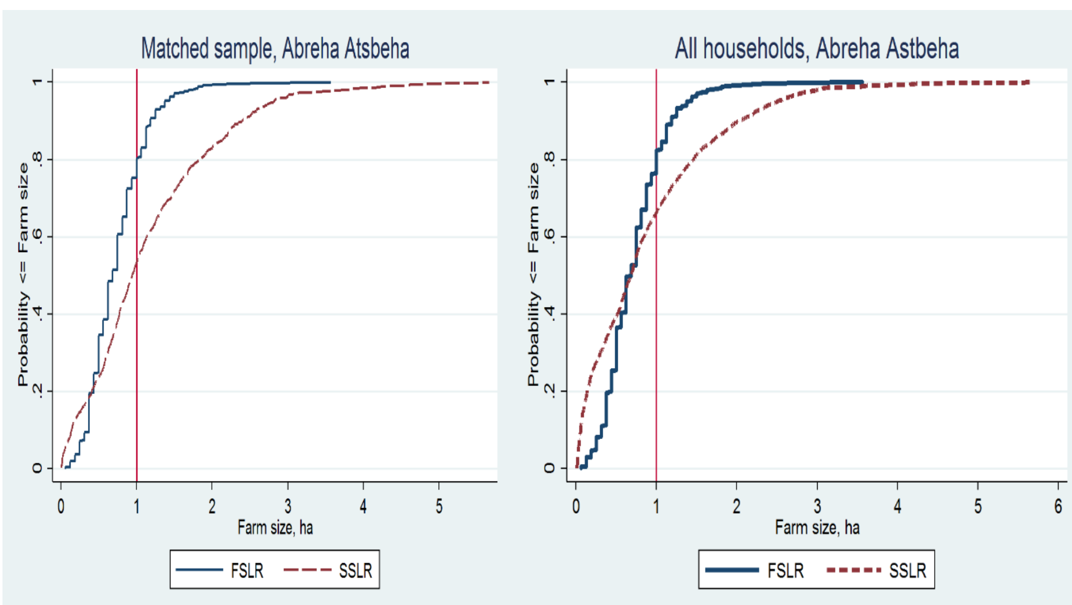

Figure 12a and b. Farm size distribution for matched sample of (old) households and all households at FSLR and SSLR in Abreha Atsbeha *tabia*.

Figure 12a and b. shows the farm size distribution of matched households in FSLR and SSLR in Abreha Atsbeha *tabia*. It shows a large increase in farm sizes for these old households and this may at least partly be due to measurement errors during FSLR. This *tabia* is known, however, for its successful program of reclaiming degraded lands. It is therefore possible that the farm size increases partly is due to allocation of rehabilitated degraded lands to the matched households. Further investigation is needed to verify this, however. 12b shows that the share of very small farms has increased but so has also the share of farms above one ha in size.

Figures 13 and 14 for Kara Adisheho and Wargiba seem to indicate that rounding errors were common while systematic under-estimation of areas may have been less of a problem. We see that the share of farms below one ha has increased from FSLR to SSLR in line with our hypothesis.

Table A*1* in the appendix gives a total overview of parcels, areas and populations by *tabia* and in total. It reveals an increase in total registered land from 13800 to 30000 ha from FSLR to SSLR. However, more work is needed to more carefully explain this large discrepancy in areas and how much is due to incomplete registration of private land during FSLR. We leave this for future research.

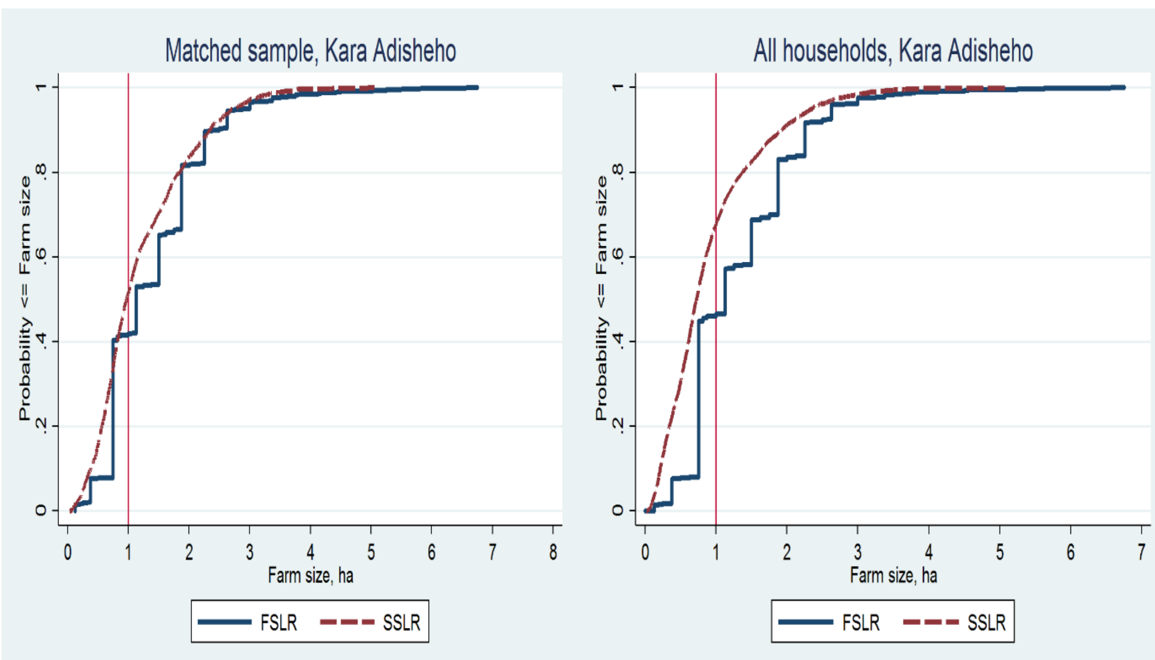

Figure 11a and b. Farm size distribution for matched sample of (old) households versus all households at FSLR versus SSLR in Kara Adisheho *tabia*

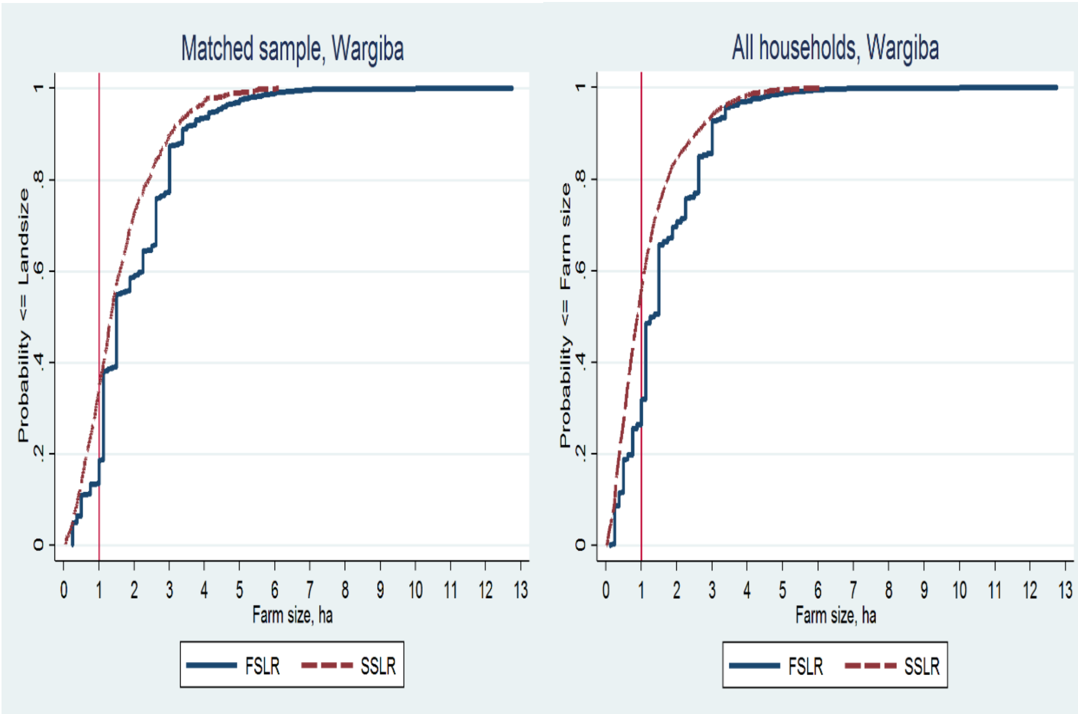

Figure 12a and b. Farm size distribution for matched sample of (old) households versus all households at FSLR and SSLR in Wargiba *tabia*

6. Conclusions

We have carried out the first comprehensive comparative assessment of First Stage and Second Stage Land Registry data in Ethiopia. It is also the first study in Africa to use land registry data to get gender-disaggregated areas of land owned. We have assessed the gender-distribution of land within male- and female headed households as well as how equitable the land distribution is among women across households, communities and the larger sample of districts.

Perhaps surprisingly, females owned as much as 48.8% of all privately held land in our sample areas in Tigray Region in northern Ethiopia. The Gini-coefficient for land distribution among women was lower than that among men (0.45 versus 0.57). The share of male-headed households with no female landowners varied from 25 to 60% across communities. Male-headed households had on average 34% more land than female-headed households but this difference was reduced to less than 10% in terms of land per capita (after correcting for differences in family size between male-headed and female-headed households).

There is a clear trend towards smaller farm sizes from the FSLR in 1998 to the SSLR in 2016. The share of farms below one ha varies from 0.50 to 0.90 across communities in the SSLR data. There is evidence of substantial measurement errors in the FSLR data, including rounding errors and downward bias in parcel and farm sizes. The extent of this problem varies across communities. The facts that community borders have changed in eight out of 11 communities, and the FSLR data include measurement errors, make it difficult to assess exactly how complete the FSLR was compared to the SSLR. Our data indicate, however, that the FSLR may have been less complete than earlier thought. Our rough estimate of total area registered in the 11 *tabias* increased from 13800 ha to 30000 ha. Further research is needed to investigate how much of this change is due to change in community borders, how much is due to reallocation of communal lands to households, how much was private unregistered land during FSLR, how much was due to measurement errors, and how much could be due to lost registry books and records in the FSLR. We can conclude, however, that the SSLR data give a much more accurate basis for planning of future land use and assessment of land distribution.

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Appendix

Table A1. Overview of parcel data, farm size data and household numbers in FSLR and SSLR

Woreda	Tabia	No. of parcels of land 1998	No. of parcels of land 2016	Parcel number annual growth rate	Total land area in ha, 1998	Total land area in ha, 2016	Land area annual growth rate	No. of households 1998	No. of households 2016	Household number annual growth rate
Raya Azebo	Bagea Delewo	2015	6220	0.065	1429	4027	0.059	1283	4324	0.070
	Kara Adisheho	4463	7400	0.028	3308	4222	0.014	2572	4624	0.033
	Wargiba	2545	4614	0.034	2144	2983	0.019	1416	2710	0.037
Degua Temben	Seret	2355	11810	0.094	557	2056	0.075	829	2909	0.072
	Arebay	3179	4681	0.022	767	1125	0.022	657	1687	0.054
	Adilal	4451	7893	0.032	989	2984	0.063	948	2610	0.058
Seharti Samre	May Kana	1069	7331	0.113	943	2351	0.052	1010	2803	0.058
	Esret	856	7433	0.128	1366	3219	0.049	838	2593	0.065
	Cheli	754	5203	0.113	596	2765	0.089	723	1815	0.052
	Tashe	1572	9018	0.102	1070	2757	0.054	1523	3347	0.045
Kilit Awlalo	Abreha Atsbeha	4334	7084	0.028	646	1512	0.048	888	1728	0.038
Total		27593	78687	0.060	13814	30002	0.044	12687	31150	0.051

Table A2. Matched sample (FSLR & SSLR) of households as share of SSLR complete household list

	FSLR	SSLR	Matched	% of SSLR matched	% of FSLR matched
Bagea Delewo	1283	4324	281	6.5	21.9
Kara Adisheho	2673	4624	1481	32.0	55.4
Wargiba	1584	2710	707	26.1	44.6
Seret	932	2909	686	23.6	73.6
Cheli	723	1815	424	23.4	58.6
Tashe	1523	3347	923	27.6	60.6
Abreha Atsbeha	888	1728	514	29.7	57.9
Arebay	656	1687	339	20.1	51.7
Adilal	909	2610	660	25.3	72.6
May Kana	1010	2803	266	9.5	26.3
Esret	351	2593	351	13.5	100.0
Total	12532	31150	6632	21.3	52.9

Source: GoE Land Registry Data, own matching and calculation.

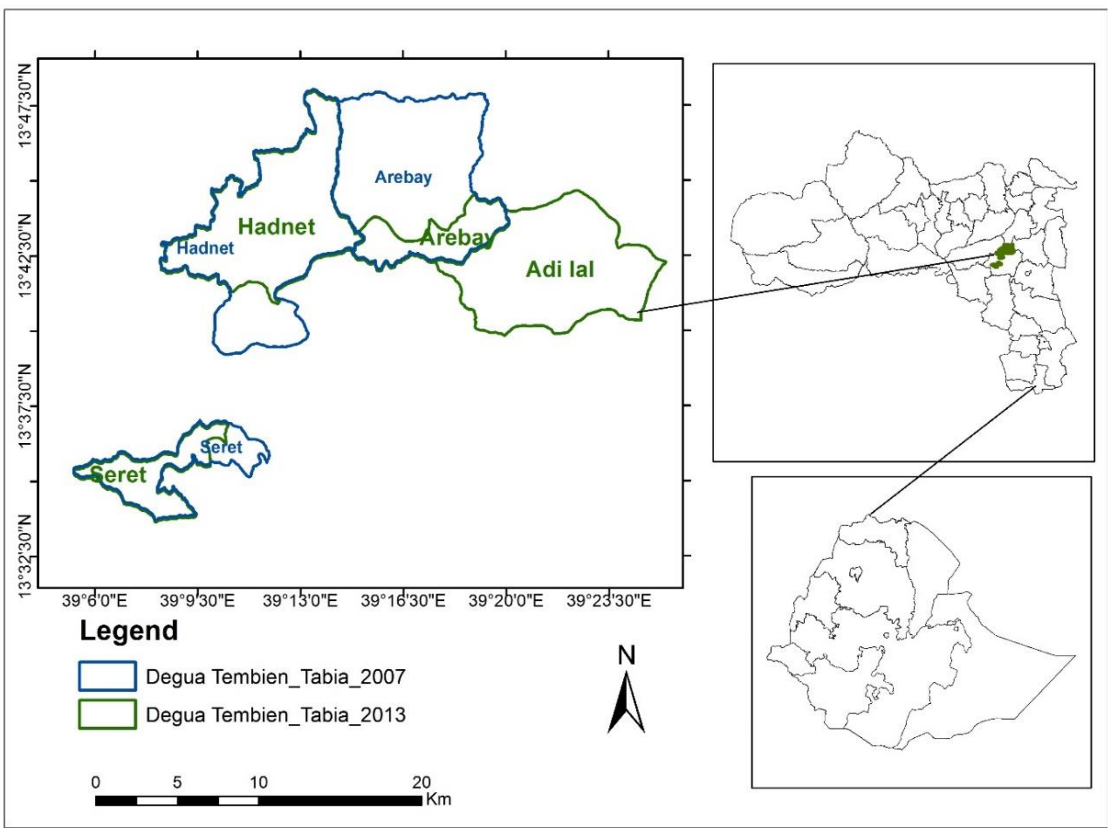

Figure A2. 1. Map of *tabias* in Degua Tembien woreda with borders on 2007 and 2013.

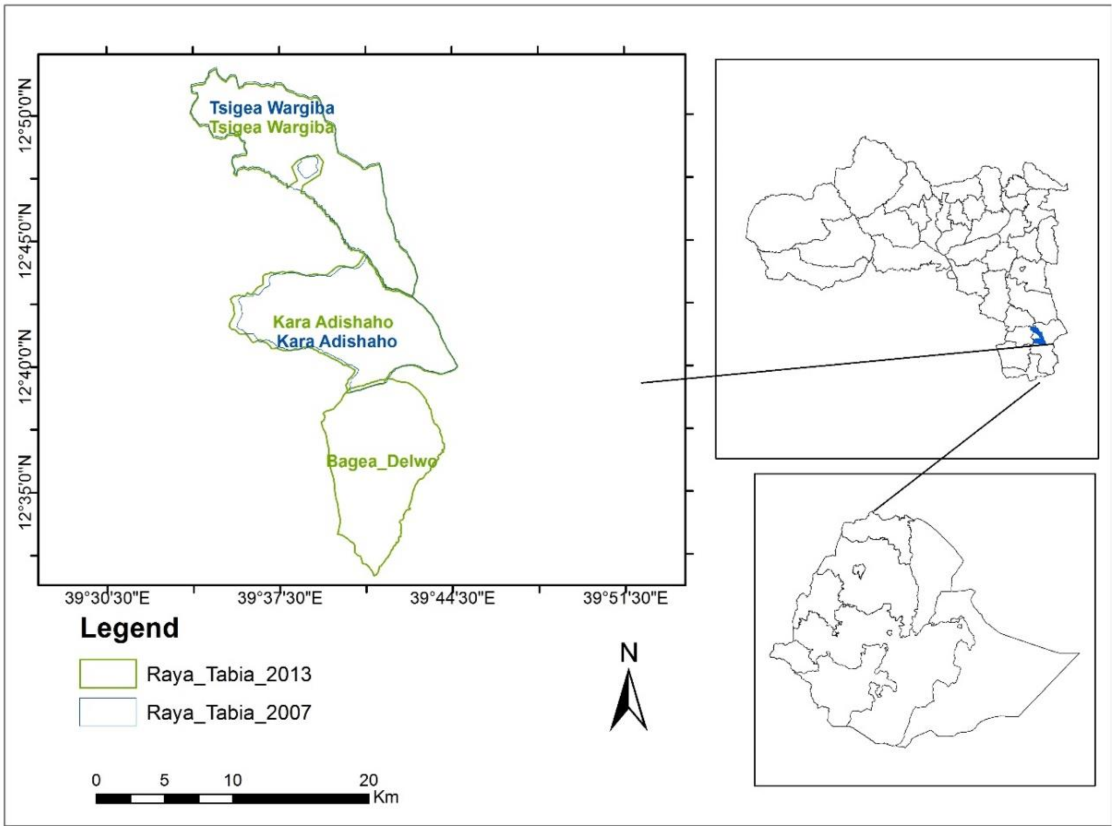

Figure A2. 2. Map of *tabias* in Raya Azebo woreda with borders in 2007 and 2013.

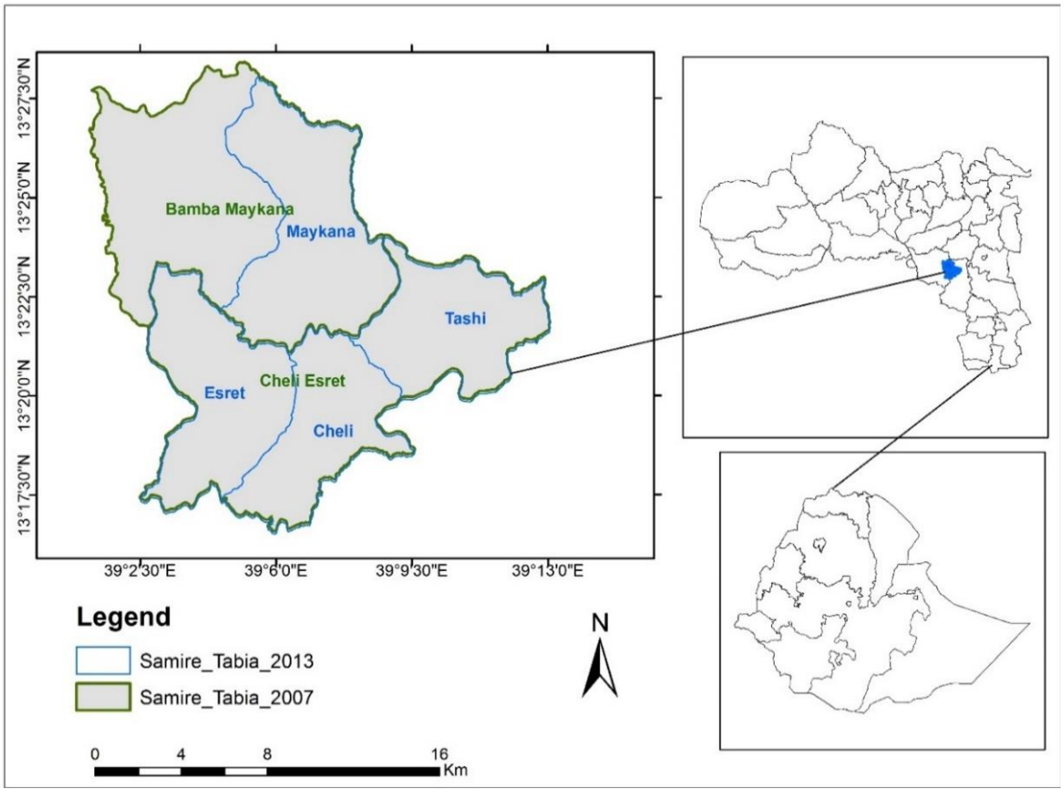

Figure A2. 3. Map of *tabias* in Samre woreda with borders in 2007 and 2013.

Table A3. Family size data in the land registry data

Tabia	FSLR			SSLR		
	mean	**p50**	**N**	**mean**	**p50**	**N**
Bagea Delewo	1.53	1	1283	3.92	4.00	4161
Kara Adisheho	1.74	2	2673	4.00	4.00	1
Wargiba	1.97	2	1584	3.53	4.00	94
Seret	4.06	4	932	3.53	3.20	2918
Cheli	4.28	4	687	4.79	5.00	1728
Tashe	2.91	2	1495	4.56	4.50	3117
Abreha Atsbeha	4.59	4	887	4.55	4.00	1646
Arebay	4.60	4	656	4.75	5.00	1662
Adilal	4.48	4	905	3.77	3.04	2610
May Kana	2.84	2	1000	4.91	5.00	2716
Esre	4.03	4	351	4.46	5.00	2593
Total	2.91	2	12453	4.28	4.00	23246

Source: GoE Land Registry data, own calculations.

Table A4. Completeness of family size data in land registries

Tabia	Total households			% with family size	
	FSLR	**SSLR**	**Total**	**FSLR**	**SSLR**
Bagea Delewo	1,283	4,324	5,607	100.0	96.2
Kara Adisheho	2,673	4,623	7,296	100.0	0.0
Wargiba	1,584	2,710	4,294	100.0	3.5
Seret	932	2,918	3,850	100.0	100.0
Cheli	723	1,815	2,538	95.0	95.2
Tashe	1,523	3,347	4,870	98.2	93.1
Abreha Atsbeha	888	1,728	2,616	99.9	95.3
Arebay	656	1,686	2,342	100.0	98.6
Adilal	909	2,610	3,519	99.6	100.0
May Kana	1,010	2,803	3,813	99.0	96.9
Esre	351	2,593	2,944	100.0	100.0
Total	12,532	31,157	43,689	99.4	74.6

Source: GoE Land Registry data, own calculations.