Measuring agricultural land inequality: conceptual and methodological issues[1]

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Abstract

Agricultural land is crucial for household welfare in many developing countries, and its distribution is a key determinant of achieving inclusive economic growth and transformation. Traditionally, measures of agricultural land inequality have centered on farm size distribution, using information from agricultural census data. In this paper, we propose a new conceptual framework for measuring agricultural land inequality, along with a set of derived indicators. These account, beyond land area, for additional aspects of land quality and land rights, and also consider the landless population. Our proposal introduces a reliable, cross-country comparable set of indicators. Its aim is to monitor the evolution of land inequality and its connection to development outcomes by utilizing data from both living conditions household surveys and agricultural censuses. Using data from five sub-Saharan African countries, results indicate overall inequality has increased. Furthermore, accounting for land with secure tenure rights significantly increases land inequality.

1. Introduction

Agriculture plays an important role in many developing economies, with most rural households depending on agriculture as part of their livelihoods strategy (De Janvry, Sadoulet and Suri, 2017).[2] About 70 percent of the population in low-income countries live in rural areas where the majority are smallholder-farm households working on land plots smaller than 2 ha (Rapsomanikis, 2015).[3] In this context, the distribution of land across the agricultural population is of great policy interest as sufficient and more equal access to agricultural land is one of the determinants of achieving inclusive economic growth, poverty reduction and increased food security.

A good measure of land inequality is central, not only to monitor the evolution of land distribution over time, but also, to better understand important development issues, including rural transformation processes. On the one hand, land inequality is part of understanding asset accumulation and its role in breaking poverty traps (Barret, Carter and Chavas, 2016), particularly in contexts where discrimination and destitution can perpetuate a landless population in extreme poverty. Further, a fairer and enlarged access to agricultural land has been linked to poverty reduction in several countries such as China, Japan, Republic of Korea, Taiwan Province of China, the Socialist Republic of Viet Nam and Thailand, contributing to economic growth (Alesina and Rodrik, 1994; Besley and Burgess, 2000).[4] There is evidence that land inequality creates low and insecure incomes for the rural poor, diminishing human capital accumulation necessary for structural transformation (Deininger and Squire, 1998; Deninger and

[1] Corresponding author: carlos.cabreracevallos@fao.org
[2] Rural African households derive two-thirds of their income from on-farm agriculture, while households in other rural parts of the world derive only one-third of their income from it (De la O Campos *et al.*, 2023; Davis, Di Giuseppe and Zezza, 2017).
[3] Average agricultural land area per capita, particularly in Africa, has shown a drastic decline between 1961 and 2018, decreasing from about 3.59 ha per capita to 0.88 ha per capita (see Ritchie and Roser, 2013).
[4] For example, Besley and Burgess (2000) in their study of Indian states, find that where there was more intensity in land reform, there was enhanced growth and poverty reduction.

Olinto, 1992). On the other hand, equality in the agrarian structure plays a role in the distribution of economic growth (Easterly, 2007a; Studwell, 2013; Deininger and Squire, 1998), at low development levels, and in the long run (Cipollina, Cuffaro and D'Agostino, 2018). Finally, land inequality is linked with environmental degradation (De Luca and Sekeris, 2012; Peters, 2004; Thomson, 2016), reduced resilience against natural disasters (Anbarci, Escaleras and Register, 2005) and increase likelihood of conflict (Ceddia, 2019; Sant'Anna, 2017).

Land inequality has been mostly analysed by assessing the distribution of farm size across operational holdings (farms), using agricultural census data (Deininger and Squire, 1998; Frankema, 2005; Lowder, Sánchez and Bertini, 2021; Lowder, Skoet and Raney, 2016). However, agricultural land inequality has multiple dimensions manifested in different forms across countries. Land inequality is not only about inequality of opportunity in accessing and/or owning any land. It is also about the quality and value of such land, as well as the different tenure and land rights associated with each parcel. Tenure reforms that secure land rights, whether statutory or customary, can have a positive impact on long-term investments, consumption and income, increasing the value of the land.[5] To the contrary, not having land rights could constraint growth and agricultural productivity, as well as efficiency. The significance of land inequality extends beyond rights and land quality. It encompasses aspects crucial to the rural population, such as their individual power to derive benefits from agricultural land. The exclusion of these populations and the lack of intrahousehold or individual-level analysis in traditional measures of land inequality, based on a sample of farms, risks underestimating the problem.

To address the drawbacks of existing estimates in land inequality, recent studies suggest using household surveys in addition to, or as alternative to, agricultural census data (Anseeuw and Baldinelli, 2020; Bauluz, Govind and Novokmet, 2020; Luiselli and Vargas, 2021). Bauluz, Govind and Novokmet (2020) provides estimates of land ownership inequality across countries both in terms of area and value, as well as accounting for the landless population. Beyond household surveys, others propose the combination of multiple sources of data or indicators. Anseeuw and Baldinelli (2020), for example, develop a methodology for measuring land inequality which considers quality of land, different land tenure aspects, and other endowments. In contrast, Luiselli and Vargas (2021) propose a multidimensional land inequality index based on a series of indicators, including land size, the diverse tenure rights, quality of land, gender inequality, and land grabbing. This approach aggregates all the different aspects and ranks the countries based on regression techniques, and assigns weights to the indicators based on statistical criteria.

However, analysing land distribution in agricultural households using household surveys, instead of agricultural censuses, also has a drawback: they don't cover data on large private corporate farms.6 This obscures the potential concentration of land by large farms, a pressing concern raised in recent literature. For example, Lowder, Sánchez and Bertini (2021) find that, using the most recent available data from agricultural censuses, farms smaller than 2 ha account for 84 percent of all farms worldwide, yet operate only 12 percent of the total agricultural land. In contrast, farms larger than 50 ha (the largest one percent of farms) operate more than 70 percent of the world's farmland. They also find that in countries with large farms, such as Brazil, the United States of America, and various European nations, land

[5] Two extensive literature reviews have shown links between securing tenure rights and outcomes such as long-term investments, better consumption, and income, although they warn that casual relation is complex to track. (Lawry *et al*., 2016; Singirankabo and Ertsen, 2020). Singirankabo and Ertsen after reviewing 85 studies, found that formalization of individual land titles can threaten 'de facto' tenure security or even lead to insecurity of tenure, and reinforce existing gendered land inequalities in detriment of overall welfare outcomes.

[6] While the unit of observation on agricultural censuses are holdings, and frequently its main objective is to determine the number, land distribution and key characteristics of holdings, including those producing at large scale, Household surveys analyse all types of households and their members. It is important to note its capability to represent agricultural households at a national scale will be condition to country specific characteristics such as the share of employment in agriculture, as well as technical features of the statistical operations such as sample, questionnaire design, etc.

concentration by large holdings is rising.7 Other studies conducted at a lower scale find similar results in Argentina, Chile, Uruguay and the Bolivarian Republic of Venezuela (Namdar-Irani et al., 2020), Paraguay (Iza Pereira, 2018), and South Africa (South Africa. Department of Rural Development and Land Reform, 2017).[8]

Similar to Anseeuw and Baldinelli (2020), Bauluz, Govind and Novokmet (2020) and Luiselli and Vargas (2021), we argue that a measure of land inequality require consideration of the different aspects in which inequality is manifested, beyond land size distribution. In addition, we are also interested in ensuring comparability of this measurement across countries, to the extent feasible, facilitating cross-country analysis and providing a comprehensive global picture on land inequality. Taking this into consideration, we propose a set of indicators that accounts the core elements relevant to land inequality. This approach leverages the most widely available sources of nationally representative information, such as census and surveys, depending on their availability for each country. We group the core elements in measuring land inequality into three. The first element is the space of the analysis, specifically the land area, along with its corresponding land quality. To assess quality, we utilize the increasingly available geospatial data to standardize land area based on features related to land quality. The second element captures the different tenure arrangements and land rights of agricultural land, using cross country comparable land rights' definitions that are akin to private ownership in contexts where land cannot be owned. The third element is the agricultural reference population, amongst whom to measure land inequality. This element captures the use of farm holdings or agricultural households as a reference population and presents different options for including the landless population. We propose alternative indicators to account for vulnerable populations concerning access to agricultural land from different perspectives.[9] The main weakness in our proposal lies in the exclusion of intrahousehold land inequality measure, specifically gender inequality. With individual-level data on land rights still being scarce globally, there is currently limited capacity to integrate horizontal aspects of inequality into a global measure.

As part of developing a proposal of a set of indicators for agricultural land inequality, this paper also contributes to the existing literature on measurement of agricultural land inequality in several ways. Firstly, we develop a conceptual framework for agricultural land inequality, providing a foundation for its operationalization and measurement on a global scale. Our overreaching goal is to maintain a level of comparability across countries. Secondly, we apply this framework to five surveys conducted in sub-Saharan African countries, contributing to the evidence on understanding agricultural land inequality in this region. Finally, we assess the feasibility of scaling up the proposed indicators to a global level by assessing the level availability of data. The full application of the land inequality indicators to global datasets is envisioned as our next step.

The remainder of the paper is organized as follows. Section 2 presents the methodological section discussing the main concepts, definitions and the proposed inequality indicators. Section 3 describes the data sources used including descriptive statistics. Section 5 presents the results and Section 6 presents the conclusion and discussion.

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[7] There are also several countries where land concentration on large holdings is strikingly high and with no indication of a decreasing trend. See for instance Faguet, Sánchez and Villaveces (2020) for Colombia.

[8] While the unit of observation on agricultural censuses are holdings, and frequently its main objective is to determine the number, land distribution and key characteristics of holdings, including those producing at large scale, Household surveys analyse all types of households and their members. It is important to note its capability to represent agricultural households at a national scale will be condition to country specific characteristics such as the share of employment in agriculture, as well as technical features of the statistical operations such as sample, questionnaire design, etc. There are also several countries where land concentration on large holdings is strikingly high and with no indication of a decreasing trend. See for instance Faguet, Sánchez and Villaveces (2020) for Colombia.

[9] Each of these element raises methodological and normative concerns that require careful analysis and definition. Most importantly, the choice of one or the other will result in systematically different land inequality indicators, each with its strengths and its weaknesses. We develop a discussion around these topics in our extended working paper.

2. Methodology: measuring land inequality

2.1. Concepts and definitions

We start by discussing land inequality, grouping the relevant concepts in two central questions: Inequality of what? and inequality among whom? (Figure 1).

Inequality of what? refers to the different categories of agricultural land10 based on the rights to own, use, and manage units of land by either holdings or households, and the space in which inequality is measured (for example, land area, land value, or both). In Sections 3.1.1 and 3.1.2, we address the concepts of landownership or land with use rights, and how do they differ from overall land access. Also, we define the measurement space – land area and land value.

Inequality of what? Land tenure rights

Households, farms, and other actors gain access to agricultural land and other resources through diverse mechanisms.[11] These entail different degrees on the rights to own, use, and manage such resources. In general, the **tenure system** determines **who** can use the land**,** for **how long,** and **under what conditions**. Each country has a unique tenure system since they are based on national written policies and laws, as well as, grounded on unwritten customs and practices (FAO, 2012). As stated by Doss *et al.* (2015), landownership, or more accurately **land tenure rights**, can be defined as a composite of various rights that extend beyond mere usage rights and encompass the right to transfer, among others.[12] These rights can interact differently with those of other people and entities, and can be characterized by different degrees of tenure security depending on national and local tenure systems (Hasanbasri *et al.*, 2022; Wegerif and Guereña, 2020).

Among these interactions, holdings and agricultural households engage in land rental and leasing activities through either formal or informal arrangements. This entails households renting out specific portions of their land or providing them free of charge to others.

As a benchmark, we focus on the **land operated** by a particular farm or household. This refers to all land used for agricultural purposes excluding land that is rented-out to others, regardless of the tenure rights held or the strategy used to access it. In other words, land operated corresponds to all the land that are used by the holding or household.

To define **strong tenure rights**, we follow the definition endorsed by FAO, World Bank and UN-Habitat (2019) that conceptualize individual *de facto* rights to land as the possession of either legally recognized documentation (**documented ownership**) or **alienation rights** over agricultural land. This is also the definition of individual rights to land used in the target indicator of Sustainable Development Goal (SDG) 5.a.1, which proxies the concept of land ownership with a core set of land rights.[13] However, given that our reference population primarily consists of households engaged in agricultural activities

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[10]According to FAO (2015), agricultural land**,** defined based on its use, includes land under temporary and permanent crops, meadows, and pastures, as well as, land under temporary fallow. It excludes land under farm buildings and farmyards, forest and other wooded land, land used for aquaculture, and other land not elsewhere classified.

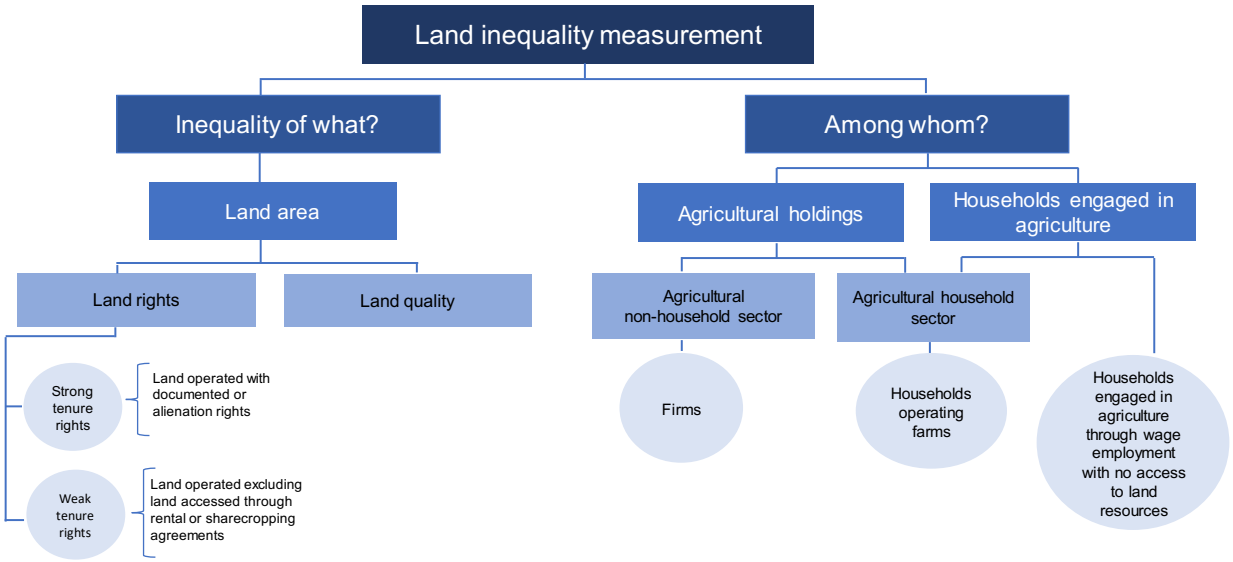
[11] For instance, households can gain access to land through the market (i.e. purchasing land), leasing or renting (paying rent to the owner); sharecropping (gaining access to land in return for paying the owner a percentage of the production), through inheritance (gaining access to land as an heir), through different types of land reform, among others (squatting illegal, received as a gift or borrowed for free, etc).

[12] Land tenure (ownership) rights can be defined from different perspectives: related to holding of use rights and (or) the ability to take management decisions, legal or formal ownership such as documentation or titling and tenure security, among others. See Doss *et al*. (2015) and Slavchevska *et al*. (2021) for a detailed description.

[13] SDG 5.a.1 has two subindicators. Subindicator a) measures the percentage of people with ownership or secure rights over agricultural land (out of total agricultural population). Subindicator b) indicate the share of women among owners or right-bearers of agricultural land.

and agricultural holdings, we define land with strong tenure rights as land for which at least one household member/holder claims documented ownership or alienation rights over the land they operate.

Figure 1. Conceptualizing agricultural land inequality



Source: Authors' own elaboration.

Considering the convention on the measurement of individuals rights to land is relatively recent, most agricultural censuses and surveys that collect information on agricultural land capture **reported landownership** instead. Therefore, due to operative reasons where no information on legally recognized documentation bearing and (or) alienation rights is available, we relax the requirement and use reported ownership as the condition to be assessed.[14]

While we acknowledge that reported ownership does not equate to documented ownership, we hope that new data, soon, will enable the measurement of land inequality in line with the comprehensive requirements of the tenure rights concept. Defining a comparable concept of tenure rights encounter conceptual challenges, further compounded by data constraints, as only a limited number of national surveys provide comparable information on land tenure rights.

Simultaneously, we define **weak tenure rights** as all the land operated, excluding that which has been accessed through rental agreements (including leases or short-term rentals) and sharecropping agreements. The rationale behind this definition is to encompass land for which farms or holdings do not provide compensation. Furthermore, this definition allows us to leverage general land tenure information typically collected in censuses and surveys,[15] providing an alternative to the definition endorsed by individual land rights.

Inequality of what? Land area and quality of land

Existing cross-country land inequality studies mostly focus on land area distribution. However, the adequacy of using land size as the sole measurement space has been contested. Recent studies highlight the need of capturing land value in land inequality measurements. For example, Bauluz, Govind and Novokmet (2020) show that comparing land size and land value leads to striking differences in land

[14] This strategy is also implemented to report of SDG 5.a.1 figures. Flagging when reported ownership is used in metadata documentation is strongly recommended.

[15] General land tenure information refers to self-declared tenure system for the agricultural land reported by informants in censuses and surveys.

inequality outcomes. This finding might suggest larger landholders have disproportionately more valuable land.

Land value refers to the market price of agricultural land. Although many developed countries have long monitored such prices through real-state registries and focalized surveys, this information is scarce in many developing countries, especially for agricultural land. As a result, previous research efforts in this direction encompassed only a limited number of countries with surveys including information on households' self-reported land value. Nevertheless, land factor endowments such as soil (Benjamin, 1995) and agroclimatic zones (Azzarri and Signorelli, 2020), types of agricultural cultivation systems (Dixon *et al.*, 2001), access to irrigation, access to markets (e.g. through roads), among others, greatly influence land value and agricultural productivity. A potential approach to overcome the data gap might require the **standardization of land area** based on the different factors affecting land quality (and thus, value). The approach can be implemented using microdata,[16] including observable characteristics at the farm level, generally collected along with agricultural land area information, or using environmental geospatial data (climate, soil, etc.).

In this study we leverage from agroedaphic suitability geospatial data (GAEZ database). We define **land quality** using crop suitability as a proxy, which is based on prevailing soil and terrain-slope conditions. The agroedaphic suitability estimations are grounded on empirical coefficients that reflect the effect of soil chemical properties and terrain conditions on crop growth and production. These estimations are thus crop/land utilization types (LUT)-specific and could be implemented for different levels of inputs and management (low, medium and high) and rain-fed or irrigated water supply systems.

To test this, we use maize as reference crop, under low level of inputs and rain-fed irrigation. The choice of maize is based on our application of the land inequality indicators to a set of countries in sub-Saharan Africa (next sections) where this crop is relevant. However, the final crop choice in future applications requires more discussion, based on potential different objectives that may include country specificity or cross-country comparability. For now, our motivation is accounting for inherent soil attributes for crop production, avoiding the indirect inclusion of other characteristics such as access to technical irrigation system or input intensive production that might introduce additional inequalities, adding bias in our results.

Crop **soil suitability** is assessed through specific evaluations of seven major soil qualities (soil quality indicators) based on relevant soil characteristics relevant for agriculture, including soil drainage characteristics[17] and soil phase occurrences[18]. These are soil nutrient availability (SQ1); soil nutrient retention capacity (SQ2); soil rooting conditions (SQ3); soil oxygen availability for roots (SQ4); presence of soil salinity and sodicity (SQ5); presence of lime and gypsum (SQ6), and soil workability (SQ7)[19].

Each soil attribute is evaluated using suitability ratings which are empirical coefficients that reflect their effect on the yield potential of a specific crop. The rating system is adapted from Sys *et al*. (1991). It ranges from 0 percent (Non suitable) to 100 percent (Non constraint). For instance, the higher the value of salinity and sodicity, the higher the constraint level; inversely, the lower the value of organic carbon, the lower the constraint, and so forth. Once the attribute is evaluated, it is aggregated on the seven soil quality indicators.[20]

Terrain suitability is estimated according to terrain-slope classes and location- specific rainfall amounts and rainfall-concentration characteristics. Rain-fed annual crops are the most critical to cause topsoil erosion, because of their cover dynamics and management. To allow to better assess soil erosion risks and to refine the terrain suitability rating scheme, the terrain-slope suitability rating captures the factors

[16] See for example, Caballero and Chávez (1980) or Chen, Restuccia and Santaeulalia-Llopis (2022).

[17] Soil drainage refers to the natural capability of a soil to remove excess water.

[18] Phases are subdivisions of soil units based on characteristics that are significant for the use or management of the land but were not diagnostic for the separation of the soil units themselves at the time they were mapped.

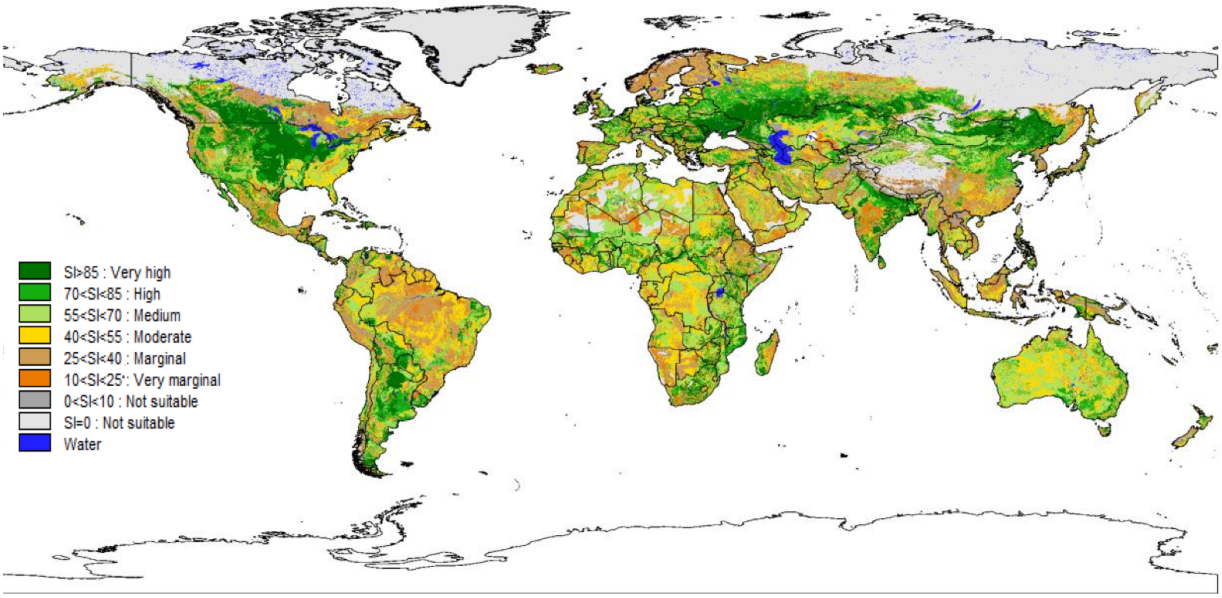
[19] See (Fischer *et al.*, 2021) fir a detailed description of the soil qualities.

[20] See Fischer *et al.* (2021) for a detailed explanation on the functional forms used to aggregated attributes.

associated with soil erosion risk which influence production and sustainability (Fischer *et al.*, 2021). This is achieved through: (i) defining, for the various crops, permissible slope ranges for cultivation, by setting maximum slope limits; (ii) for slopes within the permissible limits, accounting for likely yield reduction due to loss of fertilizer and topsoil, and (iii) distinguishing among farming practices ranging from manual cultivation to fully mechanized cultivation.

Terrain-slope evaluations are done using ratings that are defined for the eight slope range classes, namely: 0–0.5 percent very flat, 0.5–2 percent flat, 2–5 percent gently sloping, 5–8 percent undulating, 8–16 percent rolling, 16–30 percent hilly, 30–45 percent steep, and > 45 percent very steep, under low level input, rain-fed conditions, rainfall level (Fm)[21], in our case, for producing maize.

Figure 2. Soil and terrain suitability for rain-fed maize, low level inputs



Source: Fischer, G., Nachtergaele, F.O., van Velthuizen, H.T., Chiozza, F., Franceschini, G., Henry, M., Muchoney, D. & Tramberend, S. 2021. *Global Agro-Ecological Zones v4 – Model documentation.* Rome, FAO. https://doi.org/10.4060/cb4744en

Inequality of whom? Reference populations

Inequality of whom? refers to the agricultural populations that are relevant in the assessment of agricultural land inequality, and how they relate and differ from each other. This aspect is linked to concepts of vertical and horizontal inequalities (Stewart, 2000, 2016). Vertical inequality refers to inequalities within the same group of people or households, while horizontal inequality refers to inequalities among groups, typically socially or culturally defined. To examine vertical inequality, we identify two relevant groups for the study of land inequality: agricultural households and agricultural holders. For horizontal inequality, we identify the landless population as a group of interest to be further analysed.

Here, a special mention on gender inequalities in agricultural land deserves attention. While we recognize that these are a fundamental aspect within land inequality conceptualization, we decided not to propose additional horizontal inequality indicators to assess them. This is for very practical reasons: first, because validated indicators already exist, and information is already available under the SDG

[21]The Fournier index for all mapping units is grouped in six classes, namely: Fm < 1 300, 1 300–1 800, 1 800–2 200, 2 200–2 500, 2 500–2 700, and Fm > 2 700.

Indicator 5.a.1. reporting.[22] Second, the limited information about individual land rights makes adds constraints to the formulation of a global land inequality indicator.

Another fundamental aspect of horizontal land inequality is that related to communal lands, and its relationship with lands held by Indigenous Peoples (IPs). We also decide to incorporate this aspect in future work, due to lack of information. For example, the ethnicity of households or individuals is not consistently recorded in the available land data sources. Also, other types of tenure, often associated with Ips lands, including communal tenure, are too complex and difficult to collect. Recent work has started to address the lack of information with FAO-GAEZ (Le Rossignol, Lowes and Montero, 2023), so there is hope than in the future, there will be more studies on this.

Existing studies on agricultural land inequality mostly measure the distribution of land across farms, agricultural holdings, or agricultural households. Overall, these are populations directly engaging in on-farm activities, including those that operate land for agricultural purposes and/or raise livestock. The choice of one or the other is often linked with the source of information used in the analysis, namely from data of agricultural censuses or household surveys.

Agricultural censuses often collect information on holdings managed by individuals (households) or juridical personhoods (corporations, cooperatives, collectives, etc.). According to FAO (1983), they can be classified in to two sectors: the household sector, comprising all holdings operated by individuals or households; and the non-household sector that includes corporations and government institutions. For the household sector, there is usually a one-to-one correspondence between an agricultural holding and a household with own-account agricultural production activities (farm household). Nevertheless, many censuses apply a minimum size limit for the inclusion of holdings[23]. Hence, by using agricultural census for measuring land inequality, one can expect to appropriately capture the right-hand side of the land distribution (i.e large private or cooperate farms) but also omit populations operating marginal holdings.

On the other hand, household surveys, more specifically those focused on studying the living conditions of the population, collect information on all types of households in a country and tend to be representative of urban and rural areas. However, household surveys do not capture the non-household sector in agriculture, which might lead to bias in the measure of land inequality. The degree of this bias will depend on a country's agrarian structurer: if most farms are family farms or mostly farm businesses. Surveys have other advantages that censuses often do not, for example, providing information on agricultural activities, including wage employment. This makes them an ideal source for measuring vertical land inequalities as the landless or land-deprived populations can also be included in the study. Having said that, the inclusion of the landless populations in the measurement of land inequality is not a straightforward exercise. The challenge starts by defining these groups. We conclude that a proper identification of all the landless populations would require going beyond the land size they operate, or the land use rights they hold, and consider their level of involvement in agriculture.

Our literature review suggest it is convenient to differentiate between **pure landless** and **near landless** (See Annex1) according to degree to access to agricultural land. Pure (absolute) landless are mainly characterized by not operating any land. They earn income from selling labour for compensation (in cash or kind) to other agricultural households or farms and/or. For illustrative purposes only, we have operationally defined these groups as : households that do not have access to land for own-account agricultural production but have at least one household member working as wage employee in agriculture.

On the other hand**,** near landless populations**,** access to land for agricultural production. According to the tenure rights they hold over it and the land size they operate, the group comprises (i) **smallholders**, defined as those who operate marginal landholdings (in terms of size, often correlated to the value of

[22] According to FAO (2022), in the 36 countries with available 5.a.1 indicators, the vast majority (28 out of 36), show that more men than women are owners or right bearers of agricultural land. The evidence then continues to show that, in the agricultural population, women are in a disadvantaged position compared to men.

[23] The threshold is country specific, however it ranges from 1 to 2 ha.

production), and (ii) **tenants**, defined as those who operated (mostly) communal land for agricultural purposes or access to it through sharecropping or rental agreements, and/or raised livestock.[24]For illustrative purposes only, we have operationally defined these groups as :

Smallholders – agricultural households that operate less than 2 ha of land for own-account agricultural production.
Tenants – stands for those rural households with more than 50 percent of their land operated through renting, leasing and sharecropping agreements. The choice of an absolute threshold of 50 percent is arbitrary and may not necessarily reflect a status of vulnerability in all contexts.

2.2. Agricultural land inequality domains and indicators

Having introduced the relevant concepts, in this section we outline a conceptual framework for outlining different land inequality indicators, and with a global cross-country comparability goal. Our set of indicators leverage the most widely available sources of information depending on their availability for each country. These sources are 1) agricultural censuses, 2) nationally representative agricultural (farm structure) surveys, and 3) Living Conditions Surveys with agricultural integrated modules (like the LSMS-ISA countries). Table 1summarizes the description of each configuration (domains) with their population of reference and the potential sources for their computation. The actual inequality indicator can be computed in different ways, as several inequality measure possibilities exist (GINI index, Palma ration, etc.). We leave these applications in Section 4, where we apply these domains to five countries in SSA.

The first two configurations aim to depict the state of inequality in the distribution of agricultural land. Configuration one refers to agricultural land operated among **agricultural holdings**, based either on census data or nationally representative farm structure surveys. Configuration two looks at the agricultural land operated among agricultural households (as opposed to holdings), to be computed using household surveys with integrated agricultural modules[25], as an alternative data source. The rationale is comparing the inequality figures when including both the household and the non-household agricultural sector within a country, which together would capture the inequality differences driven by both large farms and firms and marginal holdings.

The third configuration emphasizes the concept of land rights for the land operated by farm households or holdings. Subconfiguration (a) considers land with strong tenure rights only; and subconfiguration (b) assesses the distribution of land excluding land under weaker tenure rights such as land accessed through renting, leasing and sharecropping arrangements. These figures being compared to configuration two might allow to unveil vulnerabilities faced by the households in the bottom of the land distribution. For instance, those households on the bottom 40 percent of the distribution might hold land rights or documents for only 50 percent of the total land operated. Likewise, these households might have access to this land mainly through rental or sharecropping agreements, paying a compensation for the land. Configuration 3 thus aims at capturing these stylized facts. The fourth configuration seeks to unveil the potential differences in land inequality when accounting for land quality for agricultural production. No specific data source is recommended for the computation of the third and fourth configurations, as more than one source may enable its computation. However, when multiple sources are available, some factors may guide the decision on which data should be used. For example, the source year in which the data was collected i.e. the most up-to-date source should be preferred; small administrative areas need to be identifiable in order to be linked accurately with georeferenced soil and climate data; and finally, the higher granularity of the data on land tenure information, the better. For example, if one source collected individual rights to land at the parcel level, this source might be

[24] Other groups as fisher folks, and petty traders, among others, have been associated with the landless populations. We exclude them from our assessment since their relationship with agricultural land is not absolute, and their livelihoods are not directly related to its de facto access but to other stages in different agrifood value chains.
[25] Or living standard surveys with information on agricultural land operated by the household.

preferable than to another source that only collected self-reported tenure system information for all the household land under operation.

Table 1. Domains of inequality, indicators, and data sources

Rationale	Indicator number	Land description	Reference population	Data source	Description
Inequality in the distribution of agricultural land	1	Land area **operated**	**Agricultural holdings** (Household and non-household agricultural sector)	Agricultural censuses or national representative agricultural/farm structure surveys	Inequality in agricultural land area operated by agricultural holdings
	2	Land area **operated**	**Households operating farms**	Living conditions household surveys with integrated agricultural modules	Inequality in agricultural land area operated by farming households
Inequality in the distribution of agricultural land rights	3	a. . Land area operated with **strong tenure rights** b Land area operated excluding **weak tenure rights**	Any	Any	Inequality of agricultural land area with strong or weak land rights operated by farm holdings (or by farming households)
Inequality in the distribution of agricultural land quality	4	Land area standardized by **land quality features**	Any	Any	Inequality of agricultural land area standardized by land quality features operated by farm holdings (or by farm households)
Inequality in distribution of agricultural land in the relevant population	5	Land area operated	Farm households **and "pure" landless households**	Living conditions household surveys with integrated agricultural modules	Inequality of agricultural land area operated by the relevant population (including farming and landless households)

Notes: The indicators proposed in this table can be computed in different ways, as these can be applied to different inequality measurement methods (e.g., GINI Index, Palma ratio, and others).

Source: Authors' own elaboration.

Finally, to address horizontal inequalities in agricultural land, we propose configuration 5. This measures inequality over the distribution of land operated by the farming/agricultural households together with households considered as absolute (or "pure") landless, for which zero land operated is imputed (e.g. locating them at the bottom of the distribution). This configuration can only rely, for now, on household survey data that include both land information, as well as labour or time use information. The latter is necessary as it allows identifying individuals that are engaged in agriculture through wage employment.

3. Application of land inequality indicators in selected Sub-saharan African countries: data and methods

Having identified the domains for a set of land inequality indicators, in this section, we describe the data and methods used compute them. To test our framework and set of indicators on agricultural land inequality, we use data from different sources: agricultural census data, household survey data, and spatial data features and indicators derived from the GAEZ database. The data is drawn for five sub-

Saharan countries: Ethiopia, Nigeria, Malawi, the United Republic of Tanzania, and Uganda. The choice of these countries is based on availability of household surveys capturing information on land area, tenure and land rights, and land quality measures. Below we describe each of these data sources.

3.1. Agricultural Census

Agricultural censuses have been intermittently conducted in the five countries under study since 1930, with the most recent statistical operation being the 2019–2020 Agricultural Sample Census (ASC) of the United Republic of Tanzania. However, except for the latter, the microdata for all the censuses is not publicly available. The only information that can be utilized comes from the statistical tables reported to the World Census of Agriculture (WCA).

The WCA, a comprehensive data compilation effort conducted by the FAO, aims to gather detailed and reliable information on the structure of agriculture in various countries. The collected data encompasses various aspects of agriculture, such as the number and size of agricultural holdings, land use, crop production, livestock numbers, and other pertinent information. Following the methodology proposed by Blanchet, Fournier and Piketty, (2022)[26], we utilize information from all WCA rounds conducted between 1930 and the undergoing 2020 WCA program to estimate Gini indexes, whenever data on the number and size of agricultural holdings are available.

3.2. The Living Standard Measurement Study-Integrated Surveys on Agriculture

The data used for this study is from the Living Standard Measurement Study-Integrated Surveys on Agriculture (LSMS-ISA). The surveys are nationally representative of the population, providing a unique opportunity to generate new insights on land inequality across the selected countries. The data provide information at individual and household level. Land rights are analysed at the household level, while labour allocation is analysed at the individual level. The data also provides agricultural information, enabling the estimation of land area that belongs to the household, both owned and cultivated, and the production of crops and livestock. Household land area is constructed using farmer subjective estimation of land size as well as with GPS land area measurement. In addition, the surveys provide detailed information about land tenure rights, including owned or rented land, or land used under additional arrangements such as sharecropping and rented in from other households. Although the LSMS-ISA provides a unique opportunity as it helps standardizing survey instruments, there are some limitations when using land ownership (or use rights) information for cross-country comparison, given that this concept can differ widely according to each country's tenure systems and population characteristics.

Table 2 presents information on the average total land area and its distribution across households by land size categories. As observed, there are differences in the average land size across the five countries. The average land size is very small in Malawi with households holding an average 0.68 ha. In contrast, households in the United Republic of Tanzania have relatively larger land holdings with an average of 2.51 ha.

In many countries, formal and informal land rights coexist. Given that the LSMS-ISA surveys do not collect information on communal or free lands, we can only analyse those accessed by each household. A problem when analysing land tenure at household level is that households may own or access lands with different tenure systems (e.g. for different plots). Despite these challenges, detailed plot level data (as available in the LSMS-ISA surveys) enables the association of the different units of land (e.g., plots)

[26] The methodology proposed by Blanchet, Fournier and Piketty, (2022) uses Generalized Pareto Curves, to recover/estimate income or welfare distributions. The minimum information needed corresponds to the number and size of agricultural holdings by size grouping.

to their corresponding land tenure system. This includes inheritance, purchase, leasing, sharecropping, and free use and squatting illegal on land.

Table 2. Average agricultural land size per farm household and distribution by land size categories

	Average land size (ha)	Land size distribution (% of households)			
		<1 ha	1–1.9 ha	2–3.9 ha	>=4 ha
Ethiopia (2018)	1.02	66	21	11	3
Malawi (2019)	0.68	81	15	3	1
Nigeria (2018)	1.26	67	15	11	6
United Republic of Tanzania (2015)	2.51	44	22	19	15
Uganda (2011)	1.51	54	26	15	6

Notes: Total land size is calculated using GPS measurements whenever available and use self-reported farmer estimations when GPS measurements were not available.

Source: Authors' elaboration based on data from World Bank. 2023. Living Standards Measurement Study - Integrated Surveys on Agriculture (LSMS-ISA). In: *World Bank*. [Cited 13 May 2023]. https://www.worldbank.org/en/programs/lsms/initiatives/lsms-ISA#4

In Table 3 we show the information at household level. Whenever a household has any land under a given tenure status, it is counted. We find significant variation across countries. In Ethiopia, Malawi and Nigeria, more than 94 percent of households access at least part of their agricultural land through ownership or use rights. This is lower in Nigeria and the United Republic of Tanzania, where on average, about 66 and 82 of households respectively own some of the land they access for agricultural activities.

Land rental is most common in Ethiopia where around 12 percent of households renting-out some of their lands and 24 percent renting-in land from other households. In Malawi, Nigeria and the United Republic of Tanzania at least 14 percent of households use rented-in land, while less than 2 percent rent-out some of their land. In contrast, in Uganda, only 1 percent of households lease their land.

Overall, this information suggests that most households access land through ownership or use rights (that is, through purchase, inheritance, grant by local leader, allocated by family member). This, however, does not take into consideration households' access (and use of) communal lands, which is also important for obtaining a full picture of land inequality. Finally, the information about rental arrangements also provides information on potential inequalities in relation to land access, and specifically, include households that could also be considered as landless if these are only using sharecropped lands.

Table 3. Average land tenure rights of agricultural land (percent of farm households with all or part of their land under a tenure feature)

	Owned/ use rights	Documented rights	With alienation rights	Rented out	Rented in	Used for free	Other
Ethiopia (2018)	94	54	79	12	24	6	1
Malawi (2019)	97	3	65	2	14	8	1
Nigeria (2018)	66	15	42	1	14	12	1
United Republic of Tanzania (2015)	82	1	14	1	16	17	6
Uganda (2011)	97	9	0	1	1	3	0

Notes: "Owned" refers to land acquired through inheritance, allocated by a family member, granted by local leader, purchased, and gift from non-household member. "Rented-out" includes land rented out and sharecropped out to other households for a short-term in exchange of receiving a rent or a percentage of the production. "Rented-in" includes land access by household through rental and sharecropped in arrangements by paying rent or a percentage of the production for the owner. "Used for free" includes land borrowed for free and used by households without permission.

Source: Authors' elaboration based on data from World Bank. 2023. Living Standards Measurement Study - Integrated Surveys on Agriculture (LSMS-ISA). In: *World Bank*. [Cited 13 May 2023]. https://www.worldbank.org/en/programs/lsms/initiatives/lsms-ISA#4

Figure 3 presents the proportion of agricultural households that belong to different landlessness status: smallholder farms, tenant households who access land mostly through tenancy or sharecropping arrangements, and the absolute landless – pure landless individuals participating in agriculture, but only employed as agricultural wage workers. The latter is reported as the proportion of landless agricultural wage workers out of the total population employed in agriculture.

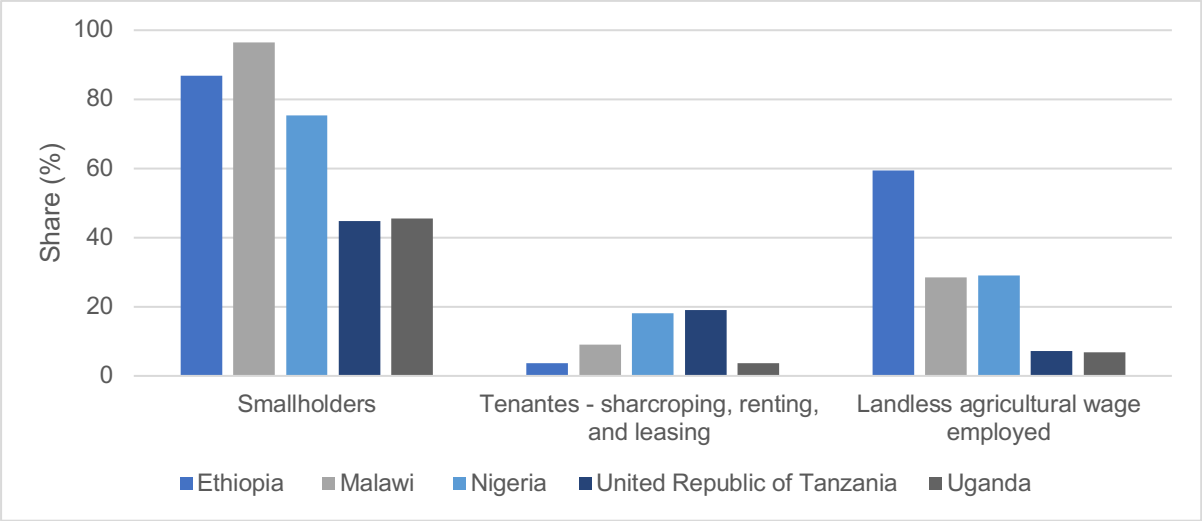
All the five countries considered in this paper are characterized by high dependency on agricultural activities including crop production and livestock rearing. In addition, in all the countries, most of the population lives in rural areas where they have access to agricultural land for their livelihoods. However, the size of their holdings tends to be small as seen in Table 2. These facts explain why the majority correspond to smallholder households in all countries.

Less prevalent than smallholder households, tenant households represent an important share of farm households in Nigeria and the United Republic of Tanzania. That is, one fifth of farm households in these countries access at least 50 percent of the land they operate through these arrangements. In contrast, shares of tenant households are relatively lower in Malawi (9 percent) and in Ethiopia and Uganda (4 percent).

Finally, the pure landless households are less common across the five countries. This is not surprising given the high rates of participation in agricultural activities and access to agricultural land in these countries.27 Yet, about 59 percent of agricultural wage workers in Ethiopia do not have access to any land, while in Malawi and Nigeria this is around 29 percent. In contrast, in the United Republic of Tanzania and Uganda, only 7 percent of the agricultural wage workers live in households that do not own any land.

[27] Even in the presence of several household members employed in agricultural activities as wage employees or unpaid-family family workers within households, as soon as one member is self-employed in agriculture, the household must have access to agricultural land regardless their type of tenure of the way it was acquired, and thus are not pure landless.

Figure 3. Proportion of relevant populations for land inequality measurement, out of total



Note: The denominator for the first and second categories – smallholders and sharecroppers/renters/leasers, is total farm households; while for the landless agricultural wage employed, the denominator is the total population employed in agriculture.

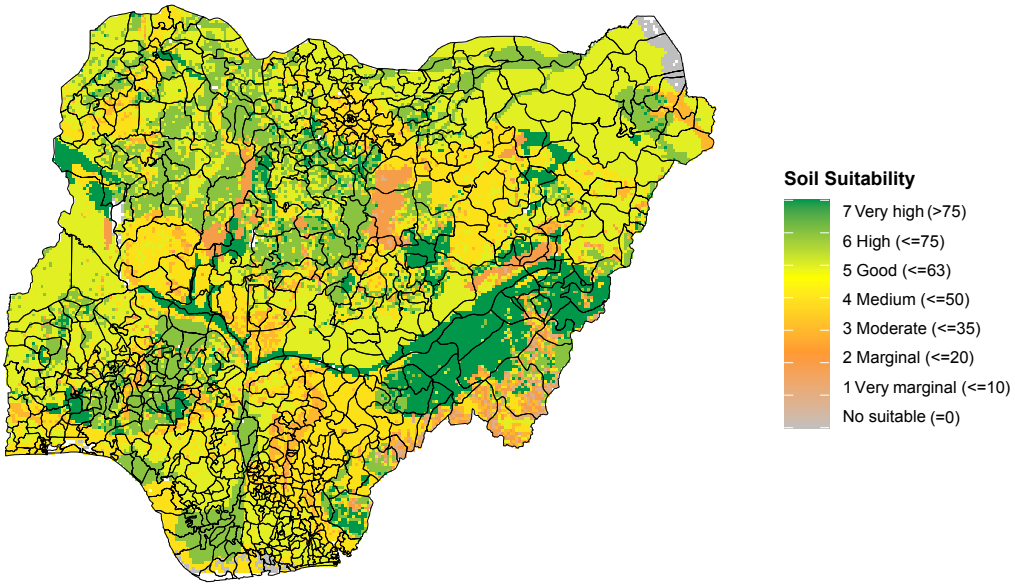
Source: Authors' elaboration based on date from LSMS-ISA household survey in Ethiopia, Malawi, Nigeria, United Republic of Tanzania, and Uganda. Inequality indexes

3.3. Land quality

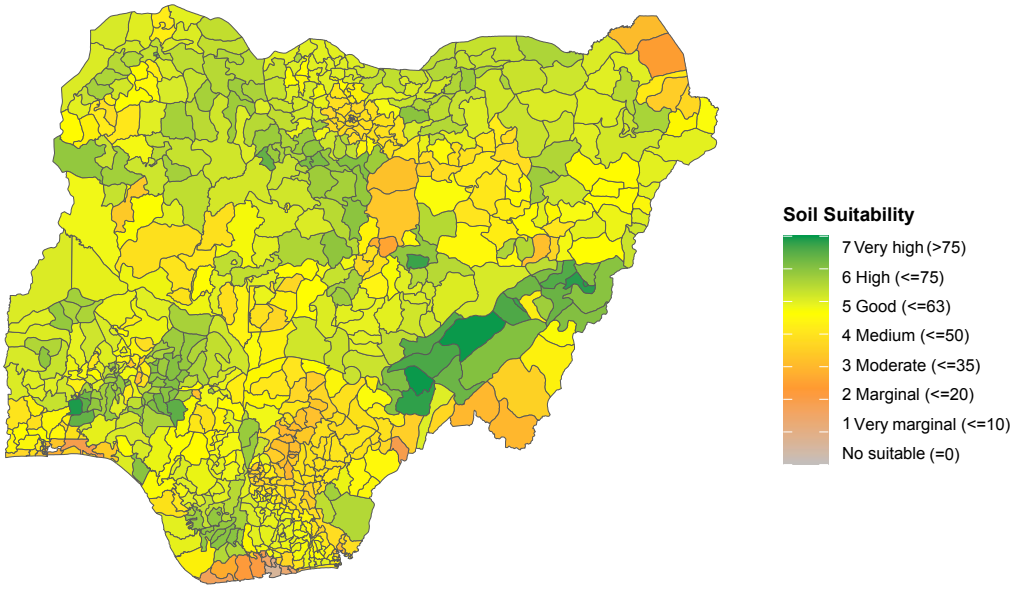
We link the crop suitability index from the FAO – Global Agro Ecological Zones (GAEZ) to survey data. Our strategy computes the index ranking average at the smallest administrative area for both, the survey and public shapefiles available. Once the averages were computed, we assigned the average ranking of the administrative area where the households are located, using the survey georeferencing information. Figure 4 presents a graphic representation of this exercise for Nigeria, with Panel A showing the suitability rankings at the grid level, with the administrative areas overlayed. Panel B shows the average suitability rankings at the administrative level.

Figure 4. Crop suitability index – Nigeria (2018)

a. Grid level



b. Administrative area level (District)



Source: Authors' elaboration based on data from World Bank. 2023. Living Standards Measurement Study - Integrated Surveys on Agriculture (LSMS-ISA). In: *World Bank*. [Cited 13 May 2023]. https://www.worldbank.org/en/programs/lsms/initiatives/lsms-ISA#4; FAO. 2023. Data Viewer. In: *FAO l GAEZ Data Portal*. Rome. [Cited 10 May 2023]. https://gaez.fao.org/pages/data-viewer. United Nations Geospatial. 2014. Nigeria [shapefiles]. New York, USA, United Nations.

4. Results

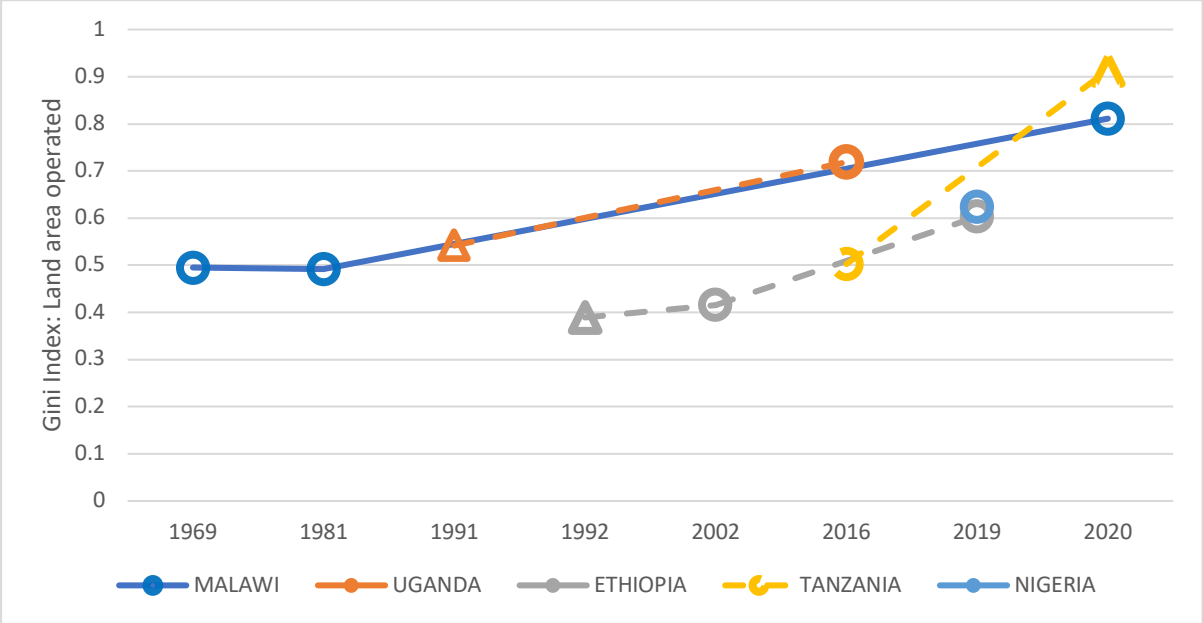
This section presents the outcomes of applying our proposed set of agricultural land inequality indicators in the five sub-Saharan countries.

4.1. Indicators 1 and 2: Inequality in the distribution of agricultural land area

Figure 5, depicts both Indicator 1 and Indicator 2 interchangeably from 1930 to 2020, using the Gini Index to measure inequality. Data points with triangle markers correspond to Indicator 1, while those with circle markers represent Indicator 2. Dashed lines are used to depict a change in the indicator configuration between years, and thus not strictly comparable data points. Although we acknowledge that, under rigorous statistical practices, both indicators should not be analyzed interchangeably, we choose to pair them recognizing that they provide valuable insights into inequality trends observed across long time periods that should not be overlooked[28].

Overall, it can be observed that agricultural land inequality trends are on the rise in the countries analyzed. Inequality has increased approximately 2 Gini points in Malawi from 1969 to 2020. Even though the non-household agricultural sector has been excluded in the Uganda and Ethiopia[29] latest point estimations, an increase of the Gini Index of at least 2 Gini points should be expected as well, considering large scale farms or firms operate larger land areas than household's farms. By looking only at the last data point available for Gini using configuration of indicator 2, Malawi is the country with the highest Inequality among those analyzed in this study. On the other hand, Tanzania is the one depicting the lowest inequality. Nevertheless, when comparing Tanzania's Indicator 1 figure in 2020, only 4 years after the latest estimation of indicator 2, the Gini index differs in about 0.4 points, indicating a significant increase if land inequality when including large scale farms and firms.

Figure 5. Gini Index by country, 1930-2020



Source: Author's elaboration based on data from the last Agricultural Census for the United Republic of Tanzania (2019–2020), WCA(1970-1980-1990 figures and the LSMS-ISA household surveys of Ethiopia, Malawi, Nigeria, United Republic of Tanzania and Uganda described in Section 3

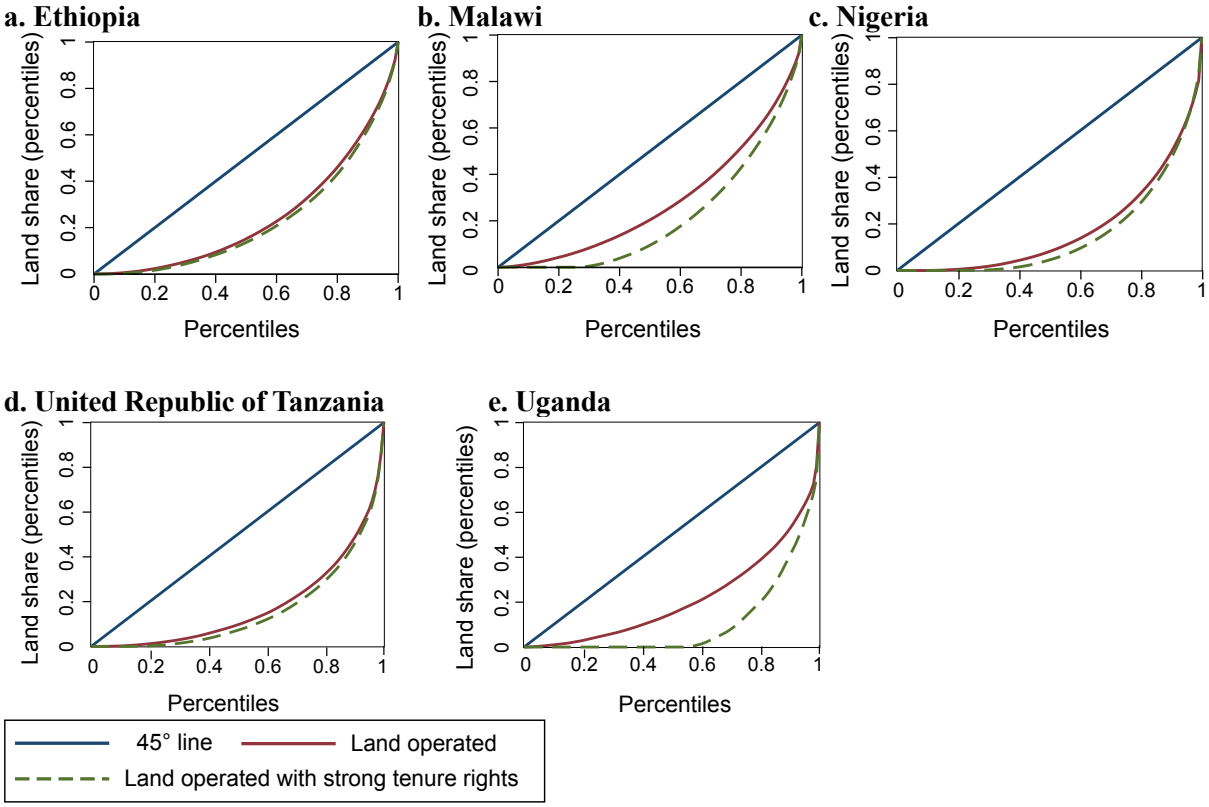
[28] This decision is informed by the acknowledgment that this example if fact illustrates real-world data heterogeneity constraints across most countries.

[29] Due to its computation with different data sources, namely agricultural census who covered the non-household agricultural sector and Living Conditions surveys with integrated agricultural modules.

4.2. Indicator 3: Distribution of agricultural land and land rights

We compare inequality of land area operated with that under the different land rights. Figure 6 shows Lorenz curves of land distributions of total operated land and land with strong land tenure rights. The results suggest that inequality increases when only land areas with strong tenure rights are considered. Also, although inequality is higher across the five countries, the level of change in the estimates varies across the five countries. When only land with documentation or alienation rights is considered, a large increase in inequality estimates is observed in Malawi and Uganda, while we see a small increases in the other countries.

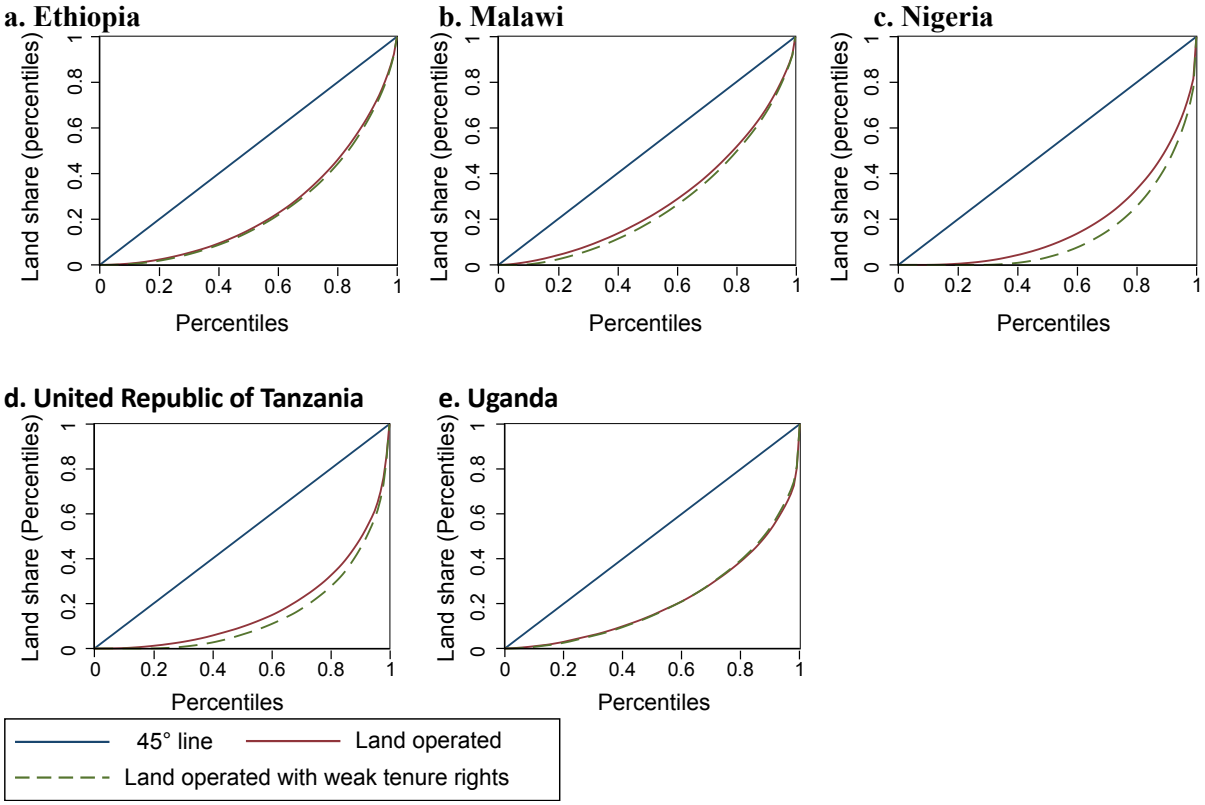
Figure 6. Lorenz curves of land operated and land with strong tenure rights (farm households)



Source: Authors' own elaboration.

Figure 7 presents inequality estimates obtained when considering weak tenure rights, i.e looking at the distribution excluding land that is accessed through tenancy, leasehold or sharecropping. The results indicate that inequality increases in Nigeria and the United Republic of Tanzania, whereas there is a small change in the lower end of the distribution in Malawi. However, we see no change in the estimates for Uganda which can be explained by the low rate of household participation in the land rental market, as can be seen in the descriptive statistics.

Figure 7. Lorenz curves of land operated and land excluding weak tenure rights (farm households)



Source: Authors' own elaboration.

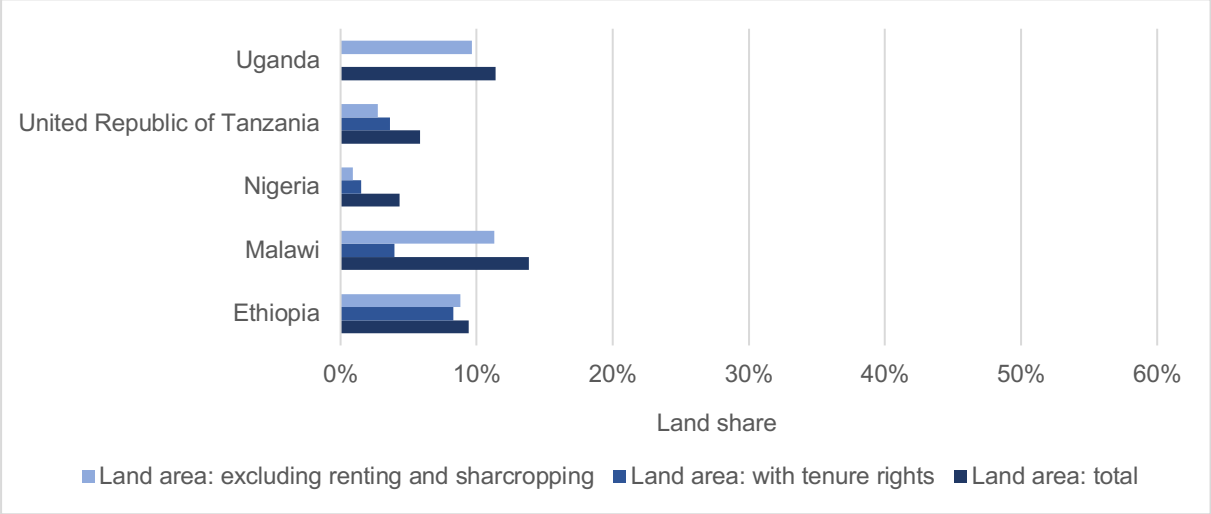
The observed changes are particularly higher at the lower end of the distribution, clearly seen in Figure 8. In Malawi, although the bottom 40 percent operates 14 percent of the total land area, these households only operate 4 percent of the land area with land rights. Similarly, the share of land operated by the bottom 40 percent significantly declines in Uganda where these group reported no land with land rights. Overall, the results show that the share of land area accumulated by the bottom 40 percent substantially declines for the five countries when land area with strong land rights is considered. In contrast, the top 10 percent share of land area with strong land rights slightly increases in all the five countries.

Overall, inequality across the countries shows similar patterns when the different types of land rights are considered. For instance, when looking at land operated with land rights, Malawi and Ethiopia are the country that depicts the lowest inequality, while Nigeria, the United Republic of Tanzania and Uganda have the highest inequality. This suggests that the three countries show relatively higher levels of land area concentration compared to Malawi and Ethiopia.

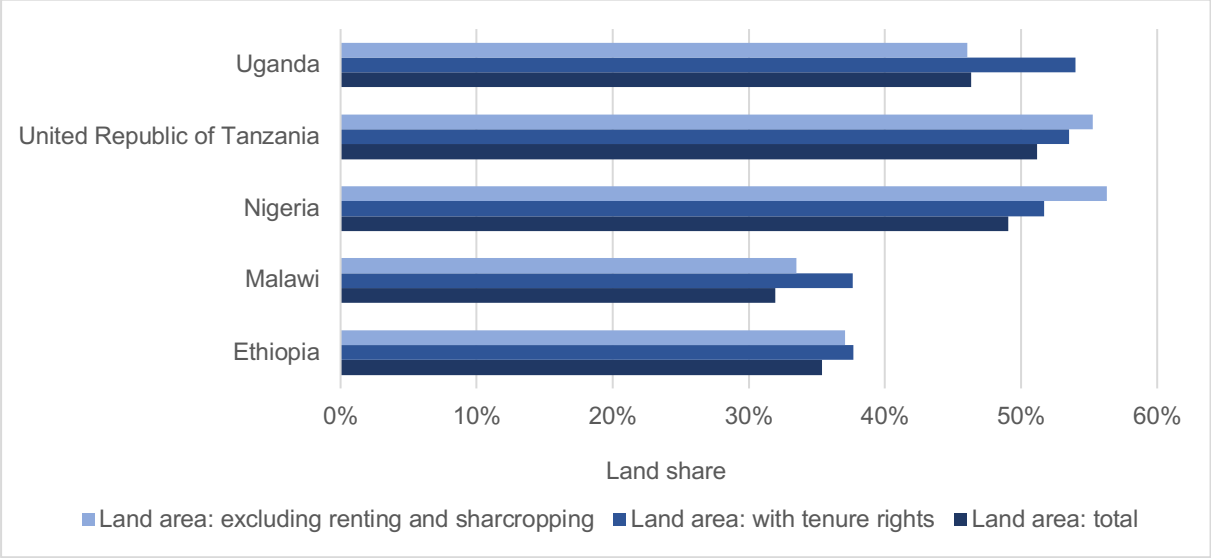
The results highlight important differences in land inequality estimates considering land rights and excluding land under rental arrangements. In all the countries, inequality increased when we consider land rights, with a large increase found in Malawi and Uganda. Another important aspect to account for is the magnitude of inequality across land typologies. It seems that considering different concepts of land rights does have an effect not only on inequality rankings but in the magnitude of the inequality depicted, as anticipated. For example, the share of land operated by the top 10 percent in Malawi is around two times bigger than the share of land operated by the bottom 40 percent. This amount becomes 9 times bigger for land with tenure rights and 3 times bigger for land operated excluding tenancy types of tenure.

Figure 8. Top 10 percent and bottom 40 percent shares of total land area operated by agricultural households: considering strong land tenure rights (Indicator 3)

a. Bottom 40 percent



b. Top 10 percent



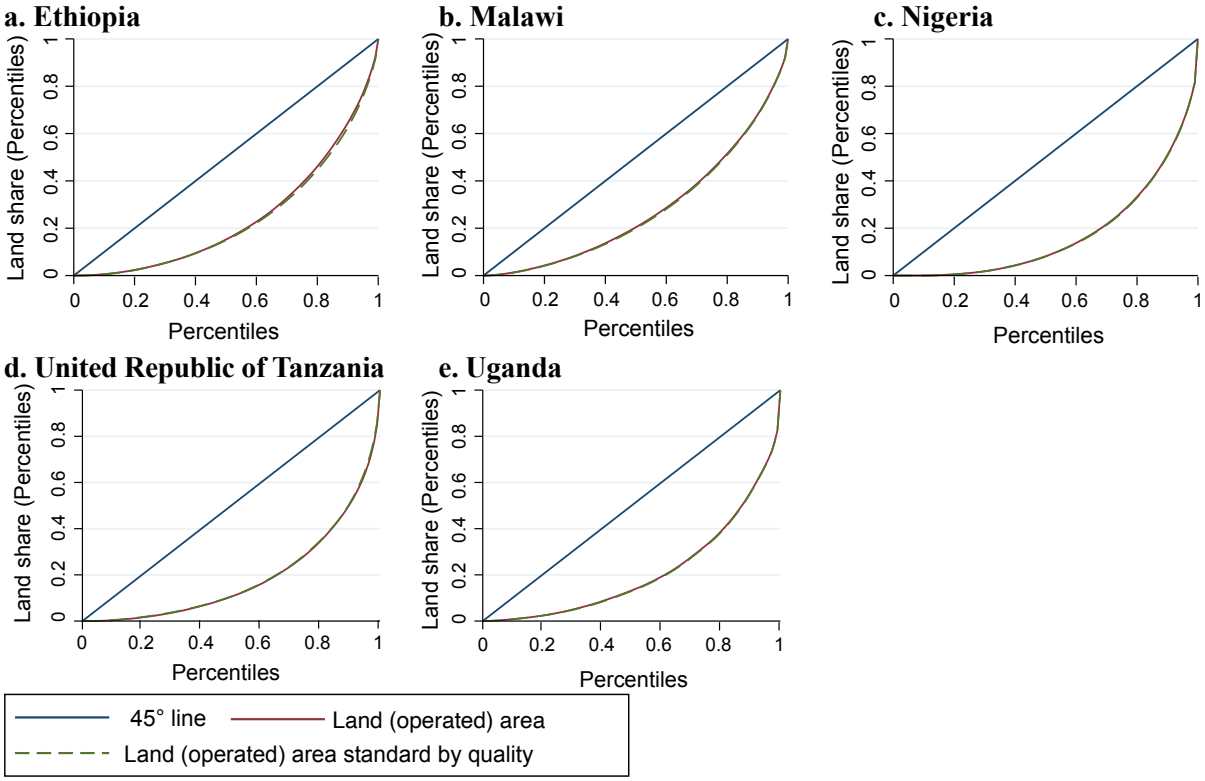
Note: The land percentiles are computed using the land operated distribution as the benchmark.

Source: Author's own elaboration based on date from LSMS-ISA household surveys in Ethiopia, Malawi, Nigeria, United Republic of Tanzania and Uganda.

4.3. Indicator 4: Distribution of agricultural land adjusted for quality of land

Figure 9 shows land inequality estimates considering the different land quality features. Surprisingly, at this stage, we find no significant effect of accounting for quality features related to land quality for maize cultivation. Figure 10 presents the results considering land quality in the distribution of agricultural land by the bottom 40 percent and top 10 percent. The share of land operated by the top 10 percent increases when land area is adjusted by land quality features in Ethiopia, Malawi and the United Republic of Tanzania, however these increases are not visible. On the other hand, the share of land area by the bottom 40 percent decreases for Malawi and Uganda, when we standardized for land quality. Nevertheless, as for the upper deciles the decrease in inequality is minor (future applications will explore other crops and include more countries from the different regions).

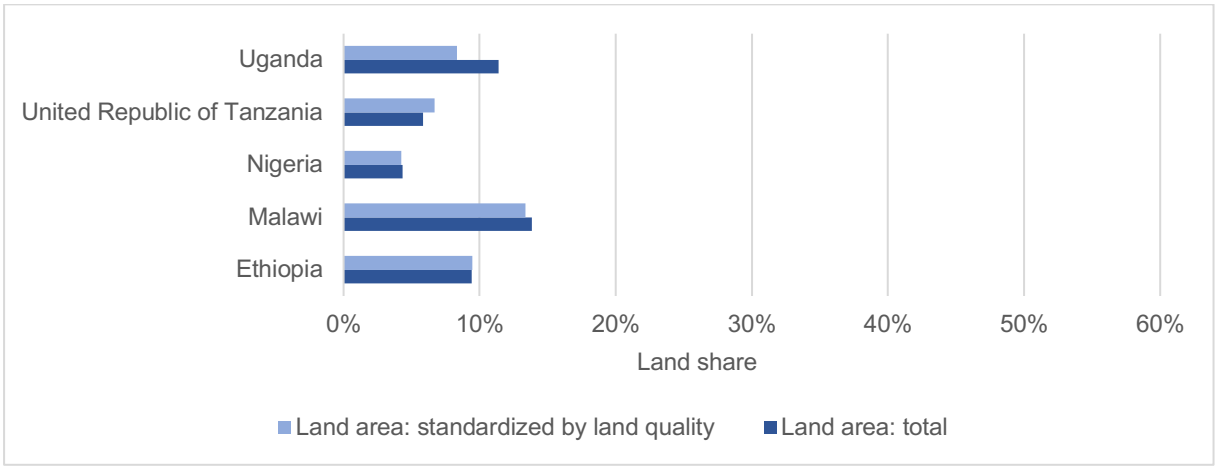
Figure 9. Lorenz curves of land area adjusted for land quality features (farm households)



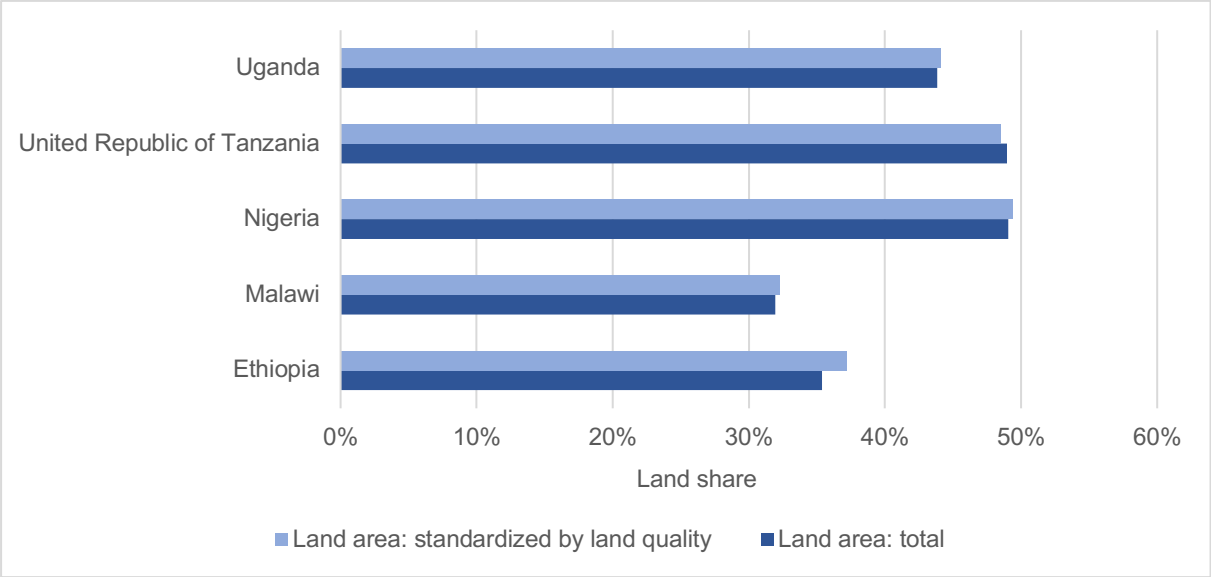
Source: Authors' own elaboration.

Figure 10. Bottom 40 percent and top 10 percent shares of land area and land area adjusted for land quality (Indicator 4)

a. Bottom 40 percent



b. Top 10 percent



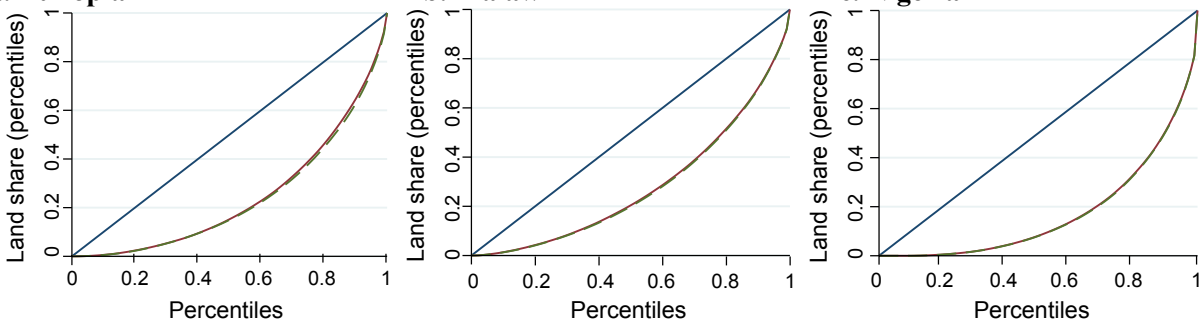
Source: Author's elaboration based on date from LSMS-ISA household survey in Ethiopia, Malawi, Nigeria, United Republic of Tanzania and Uganda.

4.4. Indicator 5: Land inequality by populations of interest (landless)

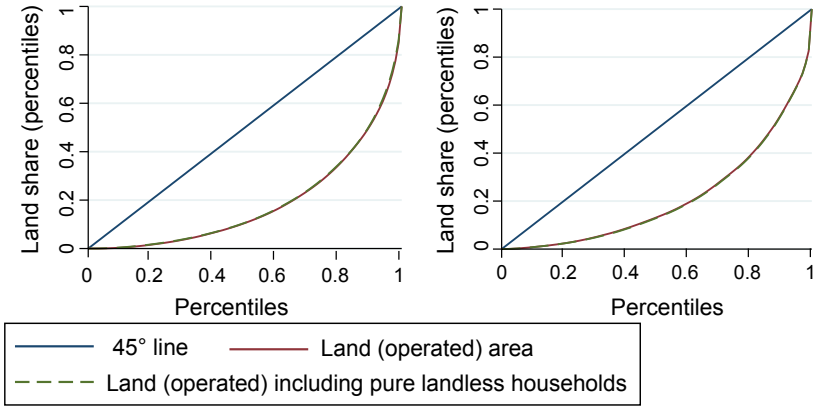
Figure 11 presents inequality estimates obtained when including pure landless households. As anticipated, Lorenz curves depict the same level of inequality, regardless of whether the landless are included. This is due to the negligible share of households that do not operate any agricultural land, but where at least one household member works as wage employee in agriculture. These results are specific for the countries analysed. Even in presence of high rates of wage employment in agriculture, these countries are characterized as well by a high rate of engagement in on-farm (crop and livestock) activities as self-employees, especially in rural areas. These findings do not disregard the importance of the landless populations. As stated by Bauluz, Govind and Novokmet (2020) the share of landless and thus the potential effects of its inclusion to measure inequality variates across regions. In fact, Ayaz and Mughal (2023) found that land inequality increases more than 20 Gini points when including the landless in Pakistan.

Figure 11.Lorenz curves of land area including the pure landless households

a. Ethiopia **b. Malawi** **c. Nigeria**



d. United Republic of Tanzania **e. Uganda**



Source: Authors' own elaboration.

5. Discussion and conclusions

Measuring agricultural land inequality is necessary to understand its drivers and dimensions. Existing studies mainly focus on estimating land inequality based on the distribution of farm size. However, land inequality is a complex phenomenon that manifests itself in many ways across countries. To account for this complexity, land inequality measurements need to incorporate the key elements of land when analysing its distribution. These key elements can be categorized in two aspects and three dimensions. First, defining inequality of what? This determines the relevance of the land features that matter for assessing land inequality and refer to both the space of analysis and land rights. The space of analysis refers land size and quality of land; while the nature of tenure and its associated land rights aims at capturing how the land is accessed including through ownership, use rights, and through formal or informal contractual agreements. It also helps to provide a sense of tenure security. Second, inequality amongst whom? Defining the reference population is quite important as its definition may omit populations of interest when considering land inequality. These can be populations of farm-holdings or agricultural households, all agricultural populations including those that are landless, and in the future, we hope to also consider populations disaggregated at individual level (men versus women) or those with populations for which most of their land is not included in household surveys or agricultural censuses given that these are managed and hold collectively, as it is the case for many indigenous populations.

These elements in our measurement design, through the proposed indicators, aimed to capture the core issues related to land inequality. First, agricultural land is not homogeneous across countries and regions, differing vastly in terms of quality and thus productivity potential. Therefore, considering only land area in inequality measurements hides land value inequalities for agricultural production. Second, agricultural households access the land they operate through diverse strategies which entail different degrees and conditions on the rights to own, use, and manage land. Therefore, looking only at only land operated hides deeper inequalities in relation to security of land tenure. Finally, the reference population used in measuring land inequality is important as it might change the picture of land inequality completely. For example, several countries have documented large-scale land acquisition processes, with large-scale farms operating a larger share of land at the expense of smallholder farmers. Also, the need for accounting the landless populations is crucial in providing a more comprehensive picture of land inequality.

This paper investigated land inequality considering land size, quality of land, land tenure rights, and relevant populations, including the landless population. We use household surveys to test this method as surveys capture most of these aspects of land as well as the landless population. The estimates provide new evidence suggesting land inequality increases when accounting for the different types of tenure. The degree of inequality varies across country with the land quality characteristics. For example, when we consider the types of tenure, land inequality increases in all countries with Nigeria exhibiting the highest inequality. The share of land accumulated by the bottom 40 percent decreases significantly in

Malawi and Uganda when land with documented or alienation rights are accounted for. Considering the distribution of land excluding those accessed through contractual agreements, the results indicate that the bottom 40 percent share decrease in all the five countries, while it increases for the top 10 percent for all countries except Uganda. These findings suggest the relevance of accounting for the different types of tenure rights. This will require relaxing the current consensus on the definition of operated land and its difference from land with tenure rights, or proxies that relate to different tenure types. Household surveys tend to collect information related to this aspect, however the way it is collected varies given the types of tenure are country specific.

Although the new estimates highlight the importance of capturing the main aspects of land, data availability remain a main challenge in covering all the proposed indicators. Data for all the indicators are not always available as our data stocktaking on the state of agricultural land data worldwide revealed. Most countries do not have all the data sources and information required to monitor all the issues presented above (and thus, all the indicators we propose).

Besides, when available, data sources that are updated periodically are the exception rather than the norm. The use of agricultural censuses or household surveys with agricultural land information, leads to a trade-off between overlooking the left side of the land distribution by using censuses (pure landless and smallholders), or the right side by using household surveys (enterprises and large-scale farms). Each source of information present caveats. Agricultural censuses, which tend to contain information on agricultural land, are usually conducted by countries every ten years, at best. Also, when available, the microdata tends to be kept within the national statistical offices, leaving researchers with the only option of working with tabulations reports, and deriving several assumptions. Household surveys with information on agricultural land, are limited to countries where agriculture represent a core sector on the employment structure.

Our proposal of a system of indicators thus intend to overcome these operative issues with more flexibility, one that mediates the need of analysis on the core aspects related to land inequality and the data availability. We propose to scale up each indicator to the extent possible and later derive conclusions from available results.

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Annex 1. Identifying the landless population

The term landless refers to a condition where there is lack of ownership of land, or lack of its access through the different use rights (Khan, Chaudhry and Qureshi, 1986). Landlessness does not necessarily represent a deprivation. In fact, it can be a development outcome depending on the context, with different consequences for inclusive rural transformation strategies (Ravallion and Van de Walle, 2008). For instance, rural population growth matched at its own pace by decent non-farm job growth makes landlessness less of a problem, even in the context of land scarcity. On the other hand, when economies are stagnant over the long term, and non-farm employment is scarce and/or poorly paid, landlessness can affect the livelihood of significant shares of the rural population even in absence of sustained population growth.

A vast part of the literature studying the issue of landlessness has focused on the phenomenon as a deprivation condition, motivated by its causes. One hand, social differentiation among small farmers under the imperative of market competition is a permanent dynamic of agrarian change, leading to land concentration and land scarcity, and different classes of rural labour, what some authors call accumulation from below. In this case, the dismantling of agricultural and rural development policies has heavily compromised agricultural profitability and increased the chance of distress sales of land assets. On the other hand, accumulation from above, like the one associated to forced eviction via non-consensual and exclusive large scale land acquisitions or destination to infrastructure projects, elite-capture over public land and land reform processes, also is a major driver of landlessness among the rural poor (Cousins, 2019; Moyo, 2016).

Landlessness and the poor in rural areas often coincide, while better-off farming households own, or have access to, a bigger land size and could earn more of their income from farming and be less likely to experience food insecurity.[30] These characteristics have influenced the landless populations to be often equated to related rural vulnerable groups such as peasants, tenant farmers, agricultural workers, etc. stretching the scope of the concept and thus hindering a consensus on a normative definition.

Our literature review suggest it is convenient to differentiate between **pure landless** and **near landless** (See **Error! Reference source not found.**) according to degree to access to agricultural land. Pure (absolute) landless are mainly characterized by not operating any land. They earn income from selling labour for compensation (in cash or kind) to other agricultural households or farms and/or. This group is often captured in surveys as "wage employed in agriculture" and provide labour to different farming systems, including small-scale farmers and large farms (e.g. plantations) or through sharecropping.

On the other hand**,** near landless populations**,** access to land for agricultural production. According to the tenure rights they hold over it and the land size they operate, the group comprises (i) **smallholders**, defined as those who operate marginal landholdings (in terms of size, often correlated to the value of production), and (ii) **tenants**, defined as those who operated (mostly) communal land for agricultural purposes or access to it through sharecropping or rental agreements, and/or raised livestock.[31]

Independently to the degree of access to agricultural land, a compressive normative definition should also account the involvement of such populations to agriculture. That is, the relevance of agriculture in the different livelihoods strategies they engage in. For instance, there might be farmers with marginal landholdings but in opportunity-led diversification strategies which operate little agricultural land (regardless of the type of tenure), but with a diversified income outside farm activities. Identifying such populations is not trivial and might require involving several variables beyond the land size, tenure

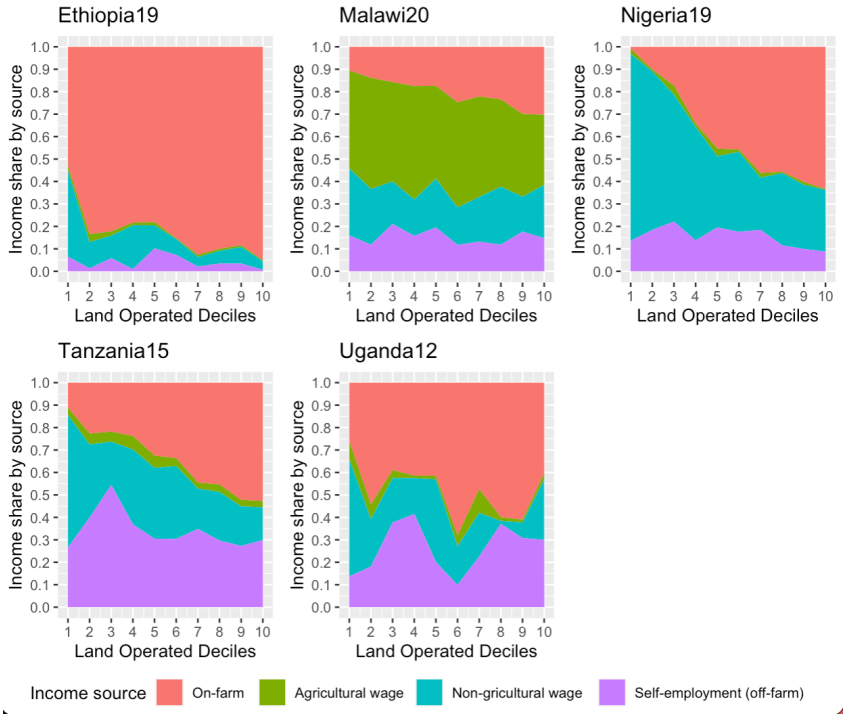
[30] There is an inverse relationship between the size of landholdings and poverty (Anwar *et al.,* 2004), livelihood diversification (Birthal *et al.,* 2014), and food insecurity (Giller *et al.,*2021). There is an inverse relationship between the size of landholdings and poverty (Anwar *et al.,* 2004), livelihood diversification (Birthal *et al.,* 2014), and food insecurity (Giller *et al*.,2021).

[31] Other groups as fisher folks, and petty traders, among others, have been associated with the landless populations. We exclude them from our assessment since their relationship with agricultural land is not absolute, and their livelihoods are not directly related to its de facto access but to other stages in different agrifood value chains.

system, and the levels of income. This represents a literature gap that need to be addressed, especially on the context of rural agricultural transformation and the current trends of agricultural land inequality.

Figure A1, presents a decomposition on income, by income sources and land deciles. In all countries except for Uganda, On-farm income increase its share with the size of land, indicating that the bottom deciles of the land distribution tend to diversify their income portfolio towards non-agricultural sources. By looking at all the sources that come from agricultural activities (on-farm income and agricultural wage), only Malawi shows a continuous share of agricultural income regardless the size of land. Nevertheless, this is due to the importance of agricultural wage.

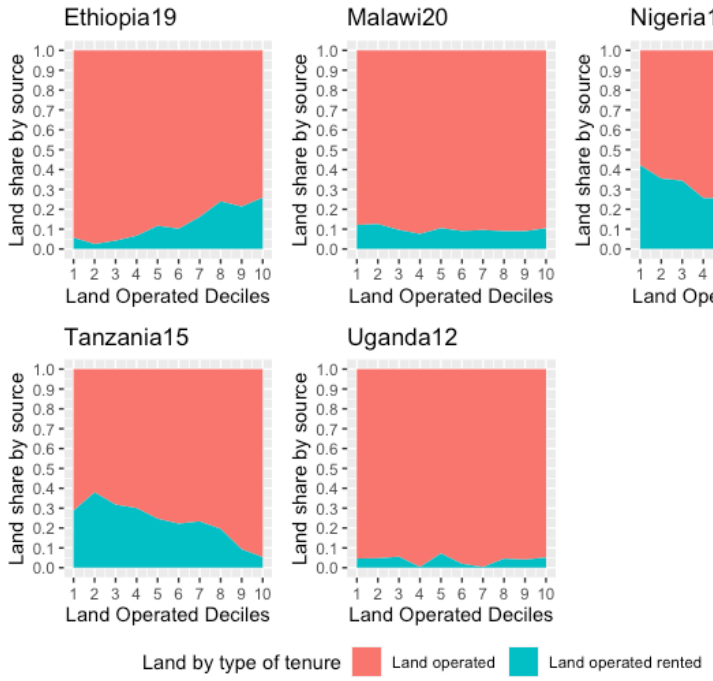
Figure A1. Income decomposition by income sources and land size



Source: Authors' own elaboration.

Figure A2 illustrates the breakdown of agricultural land operated based on whether the land is rented or accessed through sharecropping agreements, ordered by land deciles. In Nigeria and Tanzania, there's a trend suggesting that households operating smaller plots are more inclined to access land through rental or sharecropping agreements compared to those managing larger areas. This indicates that tenants are potentially a vulnerable subgroup within the landless population. Conversely, in Ethiopia, the opposite pattern is observed. In Malawi and Uganda, the distribution of rented and sharecropped land appears to be relatively uniform across different land sizes.

Figure A2. Land rented, or accessed through sharecropping agreements by land size



Source: Authors' own elaboration.

Table A 1. Landless operative definitions

Authors	No access to land	With access to land			Definition
		For livestock production	For agricultural production		
	Wage employment in agriculture	Pastoralist	Tenure rights and system	Land size (smallholders)	
Khan, Chaudhry and Qureshi (1986)	✓	✓	✓	✓	Smallholders, pastoralist, tenants (sharecroppers) and landless agricultural wage workers.
Ravallion and Van de Walle (2008)			✓		Rural households that have land other than rented agricultural land, swidden land or residential land.
FAO (2015)		✓			Holdings without any land used for agricultural production that raise livestock only on communal land.
Bauluz, Govind and Novokmet (2020)	✓				Households where at least one of its members is employed in agriculture but does not report owning any agricultural land.

Source: Authors' own elaboration.

Annex 2. The state of agricultural land data: a stocktaking exercise

Given the definition of Land Inequality (or the indicators) we have proposed and tested in the previous sections, in this annex we add more information to assess the global scalability of the set of indicators we propose. As mentioned in previous sections, the traditional source of land inequality measures are the agricultural census. This source has several advantages, given that one of the main objectives of these statistical operations such as the census is to precisely determine the number, land distribution and key characteristics of holdings, giving a complete picture of the agricultural and livestock production system.

For each FAO member country worldwide32 we list below the latest census available. **Error! Reference source not found.**, shows a world map where each country with data available is coloured in blue, by the year where the last census has been carried out. Overall, we identified 180 agricultural censuses out of 194 member countries of FAO. Therefore, using the agricultural census to measure land inequality can potentially ensure a global scalability. Nevertheless, not all the censuses are contemporary. In fact, about 40 percent of the censuses worldwide has been carried out between 2013 and 2020; other 11 percent between 2021 and 2022, mainly western European countries; and 42 censuses (23 percent) are likely to be severely outdated since they have been collected between 1950 and 2003. Countries like Guyana (1968) in LAC, Somalia (1950) in SSA, Sudan (1963) in NENA and Singapore (1973) in SAEA undertook their last agricultural censuses before 1980 that is already more than 40 years ago.

Figure A3 also depicts some regional trends regarding the availability of up-to-date agricultural censuses. Several countries in the North African region have a not conducted a census since 2005. Similarly, many of the countries in South Asia have not conducted one since 2014. Besides, agricultural microdata and metadata from census is rarely available to users. Most of the countries' National Statistical Offices (NSOs) publish statistical books with compressive agricultural figures computed, or focused software's where users can tabulate the census data. This represents a limitation for the scalability of the set of indicators proposed since several features would require accessing the microdata. Further, assessing land quality using GAEZ would also require georeferencing of the farm locations which is not available.

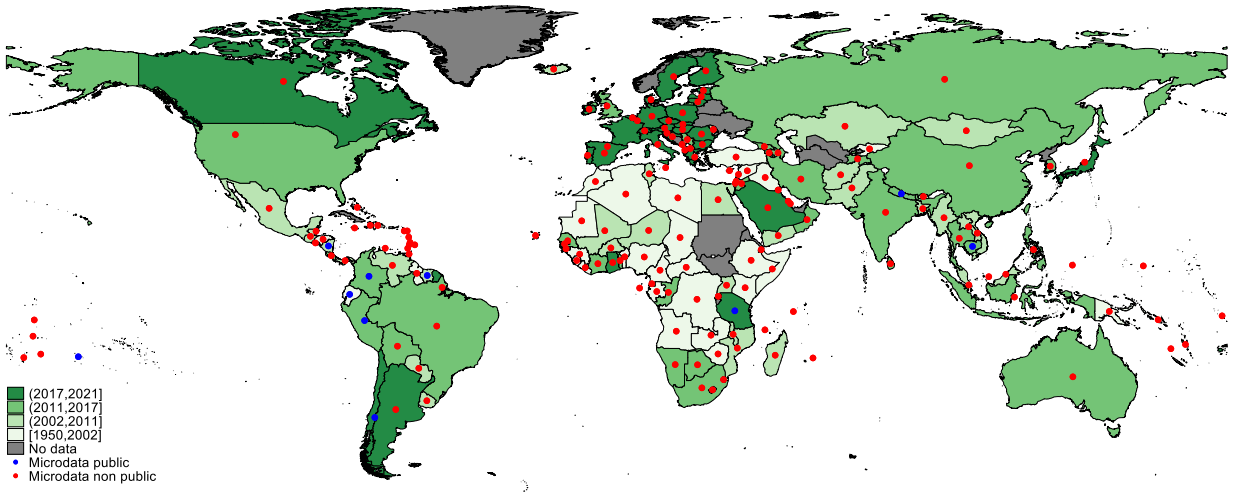
Given the limitation to access census micro and meta data, as well as the lack of contemporaneity, we have extended our stocktaking exercise to agricultural surveys and living standard surveys where information on agricultural land is collected. Like the censuses, for each FAO member country worldwide, we searched for information on agricultural land (area) and other specific information needed. For each country we assessed only the most recent survey available. If we could not access the metadata of a given survey, this statistical operation was excluded from the exercise.

Figures A4 and A5, show each a global map where the countries coloured in green indicate the countries for which available agricultural surveys and LSMS surveys are available respectively. Agricultural surveys (the SSA region and the SAEA region. Most of these statistical operations have been undertaken in between 2014 and 2020, therefore offer as well, more contemporaneity than census.

), whose main objective tends to be to update and complement the information on agricultural and livestock production of agricultural censuses are scarce at a global scale. We were able to identify only 16 statistical operations of this nature, mostly located in LAC and SSA regions. These statistical operations have been collected in more recent years compared to their census counterparts.

[32] We have completely covered the Latin American and the Caribbean region (LAC), North America region (NAM), sub-Saharan Africa (SSA), Near East and North Africa (NENA), Europe and Central Asia (ECA), South Asia and East Asia (SAEA).

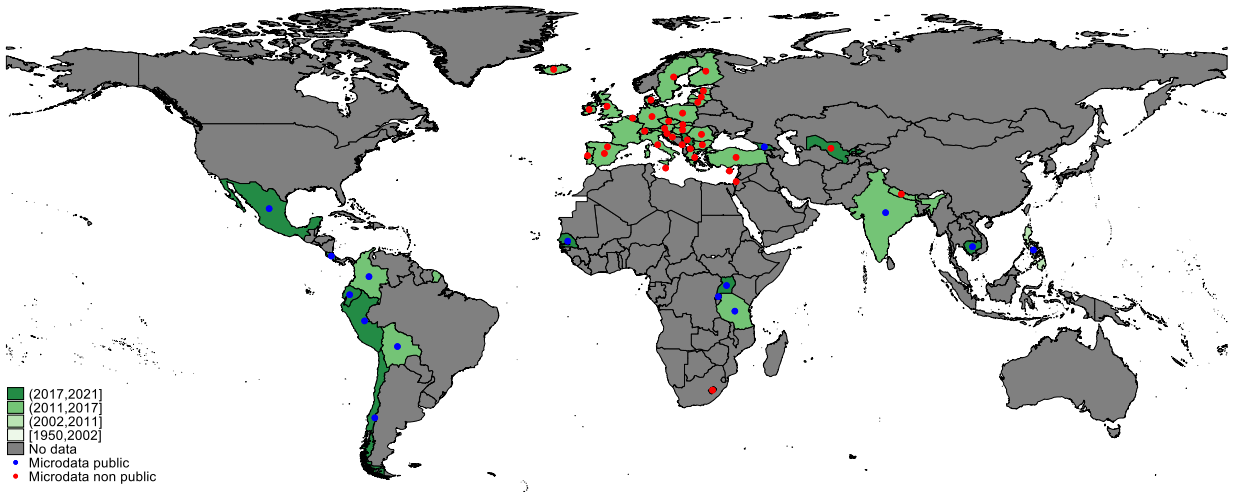
Figure A3. Agricultural census worldwide by year



Source: FAO. 223. World Programme for the Census of Agriculture. In: *FAO*. [Cited 23 May 2023]. www.fao.org/world-census-agriculture/wcarounds/census. United Nations Geospatial. 2020. World map [shapefiles]. New York, USA, United Nations.

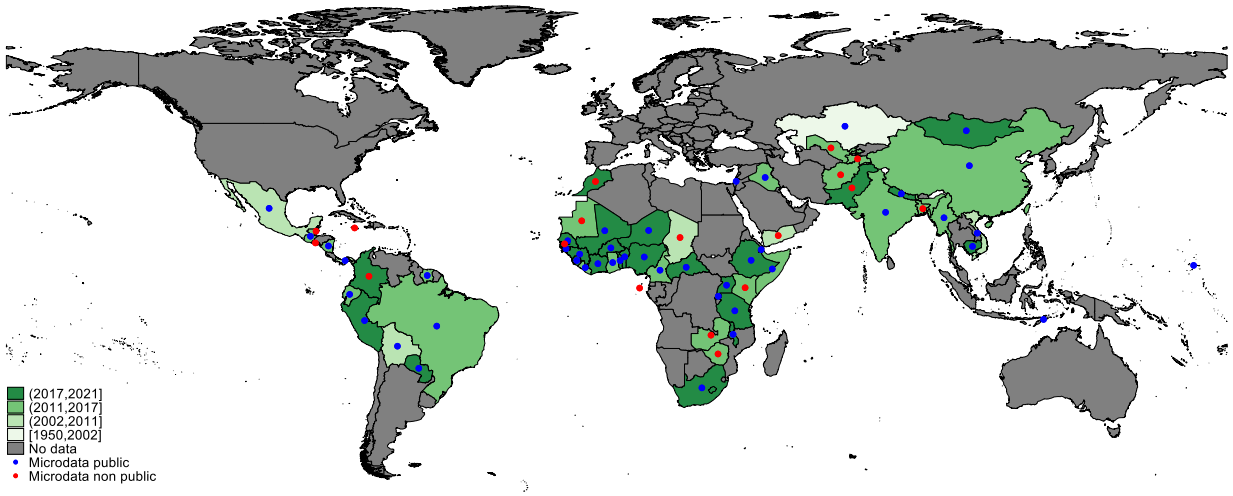
LSMS-type surveys that collect information on agricultural land holdings are more widespread across countries in comparison to agricultural surveys. This type of statistical operations are concentrated in regions where agriculture still play an important role on rural household's livelihoods. This is the case of South America in the LAC region, the SSA region and the SAEA region. Most of these statistical operations have been undertaken in between 2014 and 2020, therefore offer as well, more contemporaneity than census.

Figure A4. Agricultural surveys worldwide by year



Source: FAO. 223. World Programme for the Census of Agriculture. In: *FAO*. [Cited 23 May 2023]. www.fao.org/world-census-agriculture/wcarounds/census. United Nations Geospatial. 2020. World map [shapefiles]. New York, USA, United Nations.

Figure A5. Living Standard surveys worldwide by year



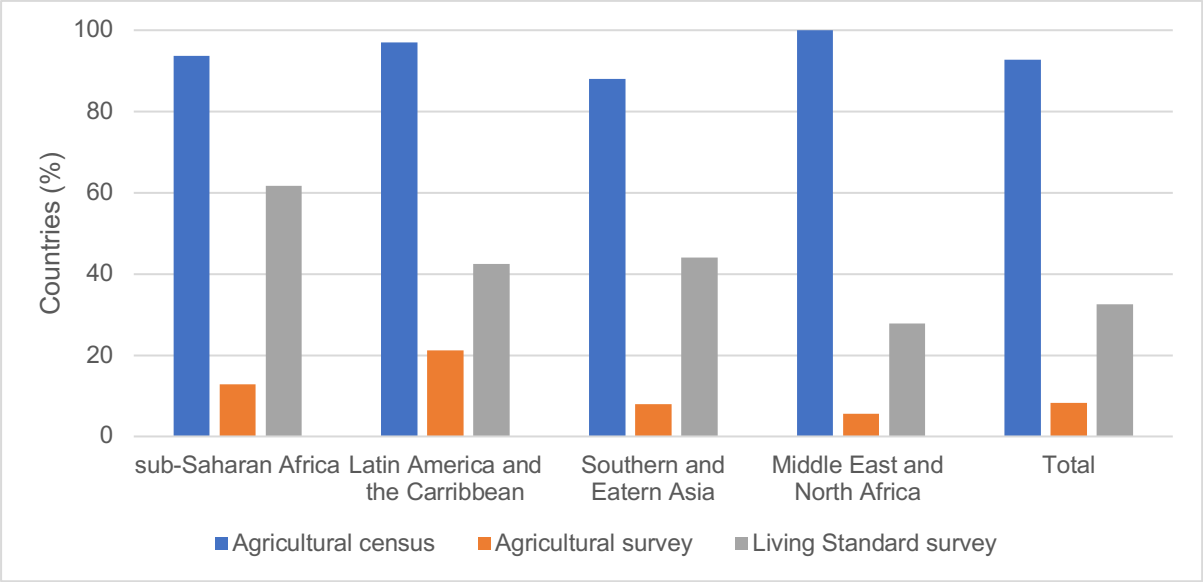
Source: FAO. 223. World Programme for the Census of Agriculture. In: *FAO*. [Cited 23 May 2023]. www.fao.org/world-census-agriculture/wcarounds/census. United Nations Geospatial. 2020. World map [shapefiles]. New York, USA, United Nations.

When comparing each type of information sources by country coverage, as the maps already reveal, the censuses offer the best country coverage. When looking at surveys only LSMS type of surveys are more widespread than agricultural surveys. This type of information sources allows to coverage of 60 percent of the country's members on SSA, around 40 percent on LAC and SAEA regions and 28 percent of the countries in the NENA region.

It is important to point out that, agricultural surveys and LSMS type of surveys are not necessarily comparable. On one hand, agricultural surveys' samples tend to be drawn from agricultural censuses, thus they are statistically representative of the agricultural structure of the country and representative to the total holdings or farms listed on them. On the other hand, LSMS type surveys' samples are generally drawn from population census focusing on a variable of interest depending on the purpose and objectives of the survey, commonly household income, or expenditures for computing poverty measures. This may not represent a limitation to the purpose of measuring agricultural land inequality, since the statistical power of the survey on agricultural statistics will depend on specific country characteristics, namely the importance of employment in agriculture in the population overall, and specifically among the poor population.

This means that when using agricultural surveys for measuring land inequality, one can mimic the results drawn from censuses and account for all the agricultural productive structure of a country, i.e., small and medium farms as well as big farms or enterprises, but overlook small family farms that operate little (less than x ha) or no land but whose livelihoods highly depend on agriculture. While when using LSMS type surveys, one would account for family farms but not necessarily big or farm enterprises.

Figure A6. Country coverage by type of information source



Source: Authors' own elaboration.

Finally, Figure A6 reports on the incidence of specific characteristics of the sources of information accessed.

Regarding land area measurement, GPS measurements, are available only for SSA region. More than half of surveys either agricultural or LSMS type identified have been measured using GPS.

A good share of the surveys identified allows assigning land area to different types of tenure (including ownership). Around 80 percent for agricultural surveys and 70 percent for LSMS type surveys. Only one third of agricultural surveys in SSA and less than 30 percent in LAC collect information on the use of agricultural land. For LSMS type surveys this percentage increases for the SSA region to more than 60 percent. Overall, 40 percent of LSMS type surveys allow to identify communal land. It is more common that surveys collect self-reported ownership at the parcel level.

Agricultural surveys, with the exception of the ones in SSA do not collect information on land ownership or right holdings at the individual level. This seems to be a feature of LSMS type surveys mainly in SSA where 80 percent of the surveys assessed ask to each individual of the household whether they own or hold rights to the land accessed by the household.

Table A2. Key information collected by information source and world region

Indicators	Agricultural surveys					Living standard surveys				
	Regions				Total	Regions				Total
	SSA	LAC	SAEA	NENA		SSA	LAC	SAEA	ENA	
Number of surveys	**6**	**7**	**2**	**1**	**16**	**29**	**14**	**11**	**5**	**63**
Statistical representativeness										
National	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Regional	66.67	71.43	50.00	0.00	62.50	86.21	78.57	45.45	80.00	71.43
Land area by source										
Farmer estimation	83.33	100.00	100.00	100.00	0.94	96.55	100.00	100.00	100.00	98.41
GPS measurement	66.67	28.57	0.00	0.00	37.50	58.62	0.00	0.00	0.00	26.98
Land area by covariates										
Land use	50.00	100.00	100.00	100.00	81.25	34.48	35.71	54.55	20.00	36.51
Type of tenure	100.00	57.14	100.00	100.00	81.25	93.10	57.14	63.64	20.00	69.84
Communal land	33.33	28.57	0.00	0.00	33.33	65.52	28.57	36.36	0.00	42.86
Land tenure										
Self-reported ownership	83.33	71.43	100.00	100.00	81.25	93.10	92.86	81.82	60.00	88.89
Documented ownership	50.00	28.57	0.00	0.00	31.25	68.97	42.86	27.27	0.00	46.03
Alienation rights	16.67	28.57	0.00	0.00	18.75	31.03	0.00	18.18	0.00	19.05
Land tenure holder information										
At the holding level	16.67	71.43	0.00	100.00	43.75	93.10	92.86	81.82	60.00	33.33
At the parcel level	83.33	28.57	100.00	0.00	56.25	82.76	35.71	45.45	0.00	55.56
At the individual level	33.33	0.00	0.00	0.00	12.5	68.97	14.29	18.18	20.00	41.27

Notes: SSA – sub-Saharan Africa; LAC – Latin American and the Caribbean; SAEA – South Asia and East Asia; NENA – Near East and North Africa; ENA – Europe and North Africa.

Source: Authors' own elaboration.