Land values and formal property rights: evidence from 22 African countries

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Abstract

The majority of African households are employed by the agricultural sector, but the uptake of formal land titles remains slow and uneven. Why do land titles remain so rare, even though they are available on demand throughout much of the continent? This paper introduces a novel measure of rural land values obtained by interacting geospatial data on crop suitability with yearly global commodity prices for 22 different agricultural products. These data permit me to measure the total attainable value for agricultural outputs, as well as the increase in potential earnings from fertilizing a parcel and from planting tree crops, at a 10 square kilometer grid cell level for every year from 2001 to 2021. Combining data from the Demographic and Health Surveys and the Living Standard Measurement Surveys provides region-level titling rates over time for 21 African countries. Previous research on the political economy of property rights has outlined a variety of likely drivers of land titling; I find no evidence of most of them. Households with more valuable landholdings are no more likely to possess a formal land title. Households whose landholdings have higher potential returns to investments are more likely to possess a formal property right, but only in areas without strong customary institutions. By showing that economic variables are insufficient to explain formalization, this paper shows how local politics affects whether households demand formal property rights.

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The rate of formal land titling varies dramatically across Africa. In Ethiopia, 79 percent of households posess such a title; in Burkina Faso, Burundi, and Malawi, that statistic is only three percent.[1] Within countries, titling rates differ across regions, even in countries at high and low levels of land titling. Despite these variations in the fraction of households with a title for their land, land titles are available on-demand to many African farmers as part of 'piecemeal' titling programs (Honig 2022*a*). What explains this uneven uptake of formal property rights?[2]

Existing literature largely adopts a top-down approach to explain the emergence of formal property rights; it studies where and why states grant formal property rights. My paper specifically adopts a bottom up, demand-side approach. Why do households seek out formal titles? I build from an important thread of the academic literature which has treated property rights as endogenous to economic variables (Libecap 1989; North 1990). At its core, this literature argues that when the benefits to participating in a formal property rights system are equal to the costs, households will formalize their property rights. I distill three variables that affect the marginal costs and benefits of land titling.

First, shifts in the value of the property should affect the likelihood of titling. If land is more valuable, then households will be more likely to dedicate resources to protecting it. Households will also be more likely to title land where the returns to potential investment are higher, to ensure that they receive the returns to such investment. In-

[1] These statistics come from the latest round of DHS and LSMS data collection, which I describe below. Across all 21 countries, 17 percent of households posessed at least one formal land title.

[2] I define 'land titles' here very broadly to mean some kind of written documentation of a claim over a parcel of land. May such rights lack some portion of the 'bundle of rights' associated with property deeds in a Western context. Some titles, such as a Senegalese déliberation foncière, are simply long term use rights which lack the right of alienability. The key term is defensibility: "the ability to defend property rights by calling on and retreiving clear property rights information, and by appealing to the state for rights enforcement" (Albertus 2020: 13).

creases in the productivity of the land should increase the likelihood that a household seeks a title for this parcel. Second, households will be more likley to title where land is under threat: where the risk of expropriation is higher, the costs of not formalizing are higher. Finally, strong customary institutions which are able to enforce property rights will decrease the marginal increase in security provided by land titles, and so the returns to land formalization will be lower in areas with strong precolonial institutions. Strong customary institutions also render households less responsive to changes in land values or the returns to titling.

To capture the value of land in sub-Saharan Africa, I create a novel, geospatial measure of the total attainable value of an agricultural parcel. Informal and illegible property markets have hampered previous attempts to generate large-scale measures of African land values. I combine data from the UN Food and Agriculture Organization on the attainable yield of 25 different agricultural products with historical commodity pricing. I take the maximum of these values at a 10 kilometer by 10 kilometer resolution to capture the maximum value of production a farmer could hope to achieve from one hectare on a yearly basis. Two related metrics capture the return to agricultural investments. The marginal increase in yields from fertilizing the parcel captures short term returns to investment, while the increase in profits from cultivating tree crops over perennial crops captures long term returns to investments.

To measure the effects of these land value data, I combine the Demographic and Health Surveys (DHS) and Living Standards Measurement Surveys (LSMS) to obtain titling data for over 160,000 households across 22 African countries. Both survey programs include questions about whether a household posesses a title for their agricultural

parcels.[3] For my full sample, I associate the survey data with my geospatial data using the average of land values across second level administrative divisions. For the subset of data which include the coordinates of enumeration areas, I calculate the average of the land variables within a 20 kilometer radius around the enumeration area.[4] To measure the risk of a household losing their land, I also include data from the Land Matrix on large scale land acqusitions, or land grabs. To capture the role of customary institutions, I use data from the Murdock ethnographic atlas.

To preview my results, I show that households in area with high returns to agricultural investment are more likely to posess a title for their agricultural land, but that the value of land itself is not associated with the fraction of households who posess a formal title. However, this effect is strongest in areas where strong customary institutions are absent. In other words, households who stand to gain the most from the agricultural investments incentivized by land titles are the most likely to formalize their parcels. However, this effect is weakly moderated by the presence of strong customary institutions. In other words, households which are situated to take advantage of land titling increasing their likelihood of receiving a return on their investment are more likely to pursue land titles. Contrary to theoretical expectations, the cumulative total of large-scale land grabs is negatively associated with the likelihood that a household posesses a formal land title. These results are largely, though not entirely, consistent across the different specifications that I enumerate above.

This paper illustrates that economic factors by themselves are insufficient to explain

[3] I also include whether a household posesses a title for their dwelling as a placebo outcome.

[4] In the appendix, I aggregate both the explanatory and outcome variables to the second level administrative division level and run the regressions both in levels and in differences. The result are qualitatively similar.

the take-up of formal land titles. Political factors, such as the strength of customary institutions, interact with underlying economic factors to drive households to seek formal land titles. These results are consistent with my broader dissertation theory. Chiefs with high levels of political legitimacy impede titling because households without titles would be more likely to bring land disputes to the formal authorities, decreasing the chiefs' long-term reservoir of political legitimacy associated with resolving disputes. Chiefs with weak political legitimacy, on the other hand, may facilitate titling as a form of development good to increase their standing among constituents (Baldwin 2016). Political legitimacy will also drive household demand for land titles: constituents of chiefs with high levels of political legitimacy will already perceive their property rights to be secure. The resulting hypothesis is that the political strength of customary elites would be negatively correlated with the uptake of land titles.

This paper advances understanding of property rights in three key ways. First, there is an expansive literature documents the causes and consequences of property rights, but much of this literature discusses property rights in abstract terms (Acemoglu and Robinson 2012; Goldstein et al. 2018; Libecap 1989; North and Weingast 1989). Acemoglu, Johnson, and Robinson (2001: 1377), for example, use "an index of protection against expropriation" as their measure of institutional quality. In contrast, this paper discusses concrete and tangible property rights: formal, written land titles. As of 2019, 53 percent of total employment in sub-Saharan Africa remains in the agricultural sector.[5] This statistic means that land tenure regimes are the form of property rights which impact the greatest number of lives across the continent.

[5]This figure comes from the World Bank's 'Employment in agriculture' statistics for sub-Saharan Africa.

Second, this paper uses newly aggregated data to test conventional wisdoms surrounding the drivers of property rights formalization. Existing studies of land tenure and formalization in sub-Saharan Africa rely on comparing case studies of specific countries. By combining LSMS and DHS data from 22 different countries across 51 distinct survey waves, this paper tests whether these existing theories are consistent with actual patterns in land titling across sub-Saharan Africa. By testing a plethora of explanations at once, this paper provides a firm footing for future studies of the political economy of property rights.

Third, this paper contributes to a growing literature on the political economy of land, property rights, and informality in sub-Saharan Africa. Existing literature of literature which explains variation in household property rights largely centers how states and elites manipulate property rights for political and economic advantages (Albertus 2020; Boone 2014; Nathan 2022; Onoma 2010). The question at the center of these studies is why and when elites supply property rights. As these newly assembled data attest, top-down explanations can struggle to explain the tremendous variation in the uptake of formal property rights between countries, regions, and even villages across sub-Saharan Africa. In contrast, this paper asks when households demand formal property rights. By illustrating when households do and do not formalize in response to changing economic circumstance, this paper emphasises the role of households in explaining variation in property rights formalization.

1 Who titles? Conventional wisdom

Existing theory posits that households formalize when the costs of formalization are equal to the benefits. Property rights condition investment (North and Weingast 1989). For households, the benefits of pursuing a formal property right is increased land security, i.e. a reduced risk of losing land. Titles may deter attemps at appropriating a household's land, and may increase the households' odds of winning any dispute which is not deterred. With a lower likelihood of losing land, households are better able to invest in their land, because they have a greater likelihood of receiving any returns to that investment. Meek (1939: 139) summarizes this logic when referring to the colonial government of Uganda's efforts to promote tree crop plantations, noting that "[The chiefs] could hardly be expected to [plant tree crops] on land which was not definitively their own."

Households face two costs when they formalize. The first cost is the administrative fee that they pay. In Senegal, for example, a land title costs approximately 5,000 CFA per hectare, or about eight US dollars. Most existing interventions subsidize these formal costs of pursing land titles.

The second, and often unrecognized cost, is that land titling carries risk. Land titling in sub-Saharan Africa is not a one-to-one mapping of existing use into written documentation. Rather, land titling involved unraveling thorny and contested problems of ownership. Often, land which has been farmed by one family for generations may be customarily 'owned' by the family whose ancestors cleared the land. Often, the former family will give the latter small gifts every year as a gesture of respect. Between these families, ownership exists within an area of strategic ambiguity. Titling forces the issue.

Because an individual pursuing a title cannot be entirely sure which family would succed in titling the land, the associated risk of losing access to the land constitutes a second cost.

I use a simple toy model to illustrate this framework.[6] This model provides a useful typology by which to categorize three existing explanations for land titling: the value of land, the risk of land loss, and the existence of customary institutions. Suppose a household can spend resources on investing in land (e_1) or in paying for a land title (e_2). Farmers have a fixed endowment of resources of $\bar{e} \in (0, 1]$. The cost of a land title is fixed, so farmers either spend e_2 on a land title or not. Farmers receive an output A from their land. A increases when households invest in their land at a rate of $\sqrt{e_1}$. There is a background risk of land being expropriated τ, but posessing a land title reduces this risk by a factor γ. The farmer seeks to maximize her output y. In this setting, the expected output can be written as:

$$y = (1 - \tau(1 - \gamma))\, A\sqrt{(e_1)} - e_2 \tag{1}$$

When the farmer does not purchase a title, this expression simplifies to:

$$y = (1 - \tau)\, A\sqrt{(e_1)} \tag{2}$$

In the case that the farmer does not title, the optimal amount of resources to invest works out to:

$$e_1^* | \text{no title} = \left[\frac{A(1-\tau)}{2}\right]^2 \tag{3}$$

[6] This exposition is largely taken from Besley and Ghatak (2010).

And in the case that the farmer does purchase a title, the optimal amount of resources to invest is:

$$e_1^*|\text{title} = \left[\frac{A(1-\tau(1-\gamma))}{2}\right]^2 \tag{4}$$

In both cases, the optimal amount to invest, e_1* is strictly increasing in the returns to agricultural investment (A) and decreasing in the risk of expropriation (τ). We can also see that the farmer always invests more if they purchase a land title because $\gamma > 0$ and this expression is increasing in γ (subject to the constraint that $e_1 + e_2 \leq \bar{e}$).

Putting these expressions together, a farmer will purchase a land title if:

$$(1-\tau(1-\gamma))\, A\sqrt{(}e_1^*|\text{title}) - e_2 > (1-\tau)\, A\sqrt{(}e_1^*|\text{no title}) \tag{5}$$

After re-arranging this equation, we obtain a critical value of:

$$e_2^* < \frac{A^2\gamma\tau(2-2\tau+\tau\gamma)}{2} \tag{6}$$

A farmer will purchase a title if the price of a formal land title (e_2) is less than this expression. If we further suppose that farmers differ in their endowments $\bar{e}$ and in their productivity A, then we can see how local economic conditions can lead to variations in titling rates.

A farmer is more likely for formalize with a higher value of A; in other words, the incentive to formalize is increasing in the returns to agricultural investment. This expression is also increasing in the risk of expropriation (τ). If the background risk of losing land is quite low, than even a highly effective title cannot have a strong effect on

the expected utility for farmers. Finally, the likelihood of formalizing is the marginal protection offered by titling (γ). If property rights institutions outside of titles—in this case, customary land tenure institutions—do a decent job protecting property rights, then the marginal returns to titling.

In this simple model, the likelihood of a given farmer seeking a formal land title depends on three values: the value of the farmer's land (A), the threat to land (τ), and the marginal protection offered by titling (γ). Beyond their use in this model, these three variables provide a useful typology for the remainder of this section, which outlines existing literature which seeks to explain the formation of property rights.

1.1 Land values

Within political economy, theories of endogenous institutions posit that property rights emerge when the individual benefits to organizing such a system become equal to the individual costs (North 1990). Shifts in relative prices can shock prevailing equilibria and drive institutional change (Libecap 1989). In the context of land formalization, this means that a shift in the value of land could drive rural households to seek formal titles for their parcels.

In sub-Saharan Africa, the role of land values in incentivizing formal property rights and disrupting customary landholding has been recognized since the colonial times. As part of his survey of the British colonies, Lord Hailey (1938: 830) wrote that "we are beginning to see new varieties of custom created by the growth of more intensive systems of cultivation, and by the fact that, in some areas at least, land is beginning to acquire a commercial value." Another contemporary observer of colonial land tenure noted that

"many subsistence agriculturalists have taken to the growing of plantation crops, with the result that land which was formerly the collective property of the group has now become the private property of some members of the group, with new rights of transfer and new rules of inheritance" (Meek 1939: 3).

Rosenthal (1992: 21) illustrates this dynamic clearly in Revolution-era France, where "it was not worthwhile to define property rights to unimproved land clearly, for enforcing such rights would have required monitoring unwarranted by the low value of the land." While the revolution created the possibility for new property rights institutions, these changes were only worth the expense in areas of high potential to return that investment. Another example comes from the American West, where mineral rights were unclear as miners staked claims during various gold rushes. Most claims were worthless. Where miners discovered gold deposits, they organically created camp administrations to arbitrate disputes, delimit boundaries, and document claims (Libecap 1989). In other words, property rights became more formalized as the value of the property increased. After the discovery of the Comstock lode, the subsequent demand for formal property right helped drive the formation of the Nevada Territorial Government—and later statehood.

The academic literature identifies this dynamic in a variety of African contexts. The perception that households will seek to title as their land becomes more valuable pervaded much of the World Bank-supported reform efforts to reform land regimes (Vendryes 2014). The relationship between land value and land titling has been made particularly explicit in Côte d'Ivoire. In 1962, president Houphouët-Boigny announced that "the land belongs to those cultivate it" in referenced to a group of Burkinabè mi-

grants who had established cocoa and coffee plantations in the center of the country. From this period until the following 1998 Ivoirian land law, these planters were the major drivers of formal property rights across the country (Colin, Le Meur, and Leonard 2009). Firmin-Sellers (1995) shows that a land-rush in Ghana led to a rebirth of customary institutions to enforce private property rights. Elsewhere, households in the Philippines "applied more for titles when crop prices rose, which also raised the value of the additional security from formal titles" (Abad and Maurer 2022: 237).

However, conceptualizing the value of land is not straightforward. The intended result of land titling programs is generally to increase investment in the land, for example fertilizing it, planting tree crops which take years to reach maturity, or leaving land fallow. Farmers may anticipate the increased prodictive capacity of the land caused by such investment. Should measures of land values capture the agricultural productivity absent the investments enabled by land formalization, or should they include the marginal returns to such investments? In this paper, I include both measures: the pre-investment land value as well as the returns to formalization.

In summary, a wide swathe of economy theory posits that land titling—and the formation of property rights more broadly—ought to be positively associated with the underlying value of the land. This literature is supported by a plethora of recent empirical papers, which largely use country-level case studies to show a relationship between property value and land titling. Using new data on both land values and property titles, this paper puts this conventional wisdom to the test.

1.2 Threats to land

The second variable I examine in more detail in the model is the level of threat to the land (τ). The toy model provides some formal insight into the relationship between threats to land and titling. Where τ is higher, households are more likely to formalize. If we assume that the value of land A is distributed unevenly across the population, then we can take this statement to mean that a greater fraction of households will seek titles. This risk of expropriation can come from other rural households, from the state itself, or from wealthy investors in pursuit of large-scale land grabs.

Much of the literature of the political economy of property rights focuses on the role of the state as the prime threat to land, most famously through Tilly's concept of the state as a stationary bandit (Tilly 1990). Strong property rights are what enables investment in the face of such risk (North and Weingast 1989). As the risk of expropriation rises, more formal institutions are required to manage the risk. Libecap (1989: 52) notes that in the Western United States, "increased settlement pressues and competition for the land... made the informal rules of ranchers insufficient for delimiting and protecting private claims." As the risk of expropriation rises, households also have to spend increasing amounts of labor or resources in guarding their property, which decreases the amount of labor or resources available for more productive uses (Besley and Ghatak 2010).

Land conflicts are an unfortunately common occurence in much of Africa. In Côte d'Ivoire for example, settlement patterns by Burkinabé and Baoulé migrants led to large scale uprisings with as many as 4,000 casualties (Boone 2003: 220). In parts of Northern Ghana, the disposession of historical elites led to conflicts between the village chiefs and the disposessed earthpriests (Lund 2008). The fact that individuals who are omre

highly placed within customary institutions feel more secure in fallowing land likewise highlights the risk of expropriation (Goldstein and Udry 2008). Similarly, Collin (2020) documents an increase in demand for formal land rights after a non-coethnic moves into one's neighborhood. Such concern over an inability to sanction non-coethnics without juridical support highlights a concern over potential conflicts.

Formal property rights can help alleviate such concerns. The legibility itself inherent in formal property rights can enhance the perceived security of holdings, regardless of the actual utility of titles (Ferree et al. 2023; Honig 2022*b*). In Ghana, households in land conflicts often make reference to the state in order to support their land claims (Lund 2008). Such claims can be particularly effective in areas where the state is largely scarce: being the first household to posess a land title may be more useful than being the 50th (Nathan 2022). When one's status within customary institutions is already high, however, it may be less necessary to leverage land claims to win conflicts (Honig 2017); the chief's cousin does not need help protecting land.

The relationship between land titling and perceived land title security is well documented. In a meta-analysis of the impact evaluation literature, Lawry et al. (2017) show that beneficiaries of land formalization programs have consistently lower perceived risks of land expropriation. This relationship is also the key mechanism through which land titling impacts agricultural investment and productivity (Ali, Deininger, and Duponchel 2017).

Together, this literature illustrates how the risk of expropriation can drive demand for land titling. If an individual is more concerned about losing land, it makes sense that they would have more reason to protect it. This link between the risk of expropriation

and titling has a strong grounding in theory. However, practical difficulties often prevent a direct test of this linkage.

1.3 The role of customary authorities

The third factor that I associated with household incentives to title is the extent to which titles actually reduce the risk of losing land (γ). This factor will be lower in areas where customary institutions are strong, because customary elites can often enforce property rights (Firmin-Sellers 1995). In other words, if customary institutions are successful in enforcing property rights, then formalizing property rights will have a lower marginal increase in land tenure security, decreasing the benefits of pursuing a formal title relative to the costs.

Albertus (2020: 105) explicitly notes that one "circumstance in which demand for land titles can be low is where existing informal land rights are more capacious than the rights and tenure security that are offered from a formal titling program." In other words, strong informal institutions may reduce the benefits of formal titles where the tenure security provided by informal institutions is decent. Individuals may also explicitly prefer informal institutions if they perceive them to be quicker, more responsive, or more amenable to their claim (Winters and Conroy-Krutz 2021). They may also prefer the ability to forum-shop between competing institutions. Where formal and informal institutions overlap, individuals can take advantage of the resulting legal pluralism to support claims which may otherwise be dubious (Lund 2008). In some circumstances, chiefs may themselves issue a written title. These titles may increase perceived security regardless of their legal weight (Honig 2017).

Preferences for informal institutions also problematize the idea that formal titles are necessary or sufficient for land tenure security.[7] Individuals with formal titles do not always have secure tennure, and the titling process itself may advantage some households over others (German and Braga 2021; Meinzen-Dick and Mwangi 2009). Informal regimes are often flexible and well-adapted to local circumstances (Colin, Le Meur, and Leonard 2009). Informal institutions may even have internal checks and balances via overlapping authorities. Earthpriests in Ghana, for example, can provide a counterweight to chiefs (Lund 2008). It is important to note that effective informal institutions are not unique to Africa. In rural Northern California, for example, ranchers generated norms and institutions to manage stray cattle and resolve disputes (Ellickson 1991).

Finally, the chiefs themselves may resist titling. Chiefs can use their position as development intermediaries to extract rents (Nathan 2022). Chiefs also often use control over land allocation as a sanctioning mechanism, enhancing the power of the customary institutions in other areas (Acemoglu, Reed, and Robinson 2014). This provides an incentive for chiefs to resist titling because it can reduce a chief's moral authority or their ability to coerce. On the other hand, "each negotiation over land presents an opportunity for customary authorities to benefit personally from the converstion of customary land" (Honig 2022*a*: 86). Strong hierarchical customary institutions, however, can constrain individual chiefs via accountability mechanisms. Strong customary institutions can reduce titling regardless of the incentives or machinations of individual chiefs.

To summarize, by providing and enforcing reasonably secure informal property rights,

[7] Of course, customary elites may also fail to provide adequate property rights. Strong customary elites face the same fundamental commitment problem as individuals: any institution strong enough to enforce property rights is strong enough to take them away (J. B. Murtazashvili and I. Murtazashvili 2021).

strong customary institutions may decrease the marginal benefits to titling. Where land is already reasonably secure, the incentive to title is less. As a result, I expect lower titling rates in areas with strong customary institutions, and that households in such areas will be less responses to changes in land values or the returns to fertilization.

2 Data sources

A lack of available data has hitherto hampered cross-national studies of land titling and property rights formalization in Sub-Saharan Africa. To overcome this hurdle, I combine four sources of data to test for evidence of these mechanisms at work. To measure land titling, I merge data from the Demogaphic and Health Surveys and Living Standards Measurement Surveys to generate comparable, cross-national survey data on the fraction of households who posess a formal land title. To measure land values, I introduce a novel geospatial measure of potential agricultural values by combining global commodity prices with crop suitability metrics. I capture threats to land and the strength of customary institutions using existing data, chiefly the Land Martix dataset of large-scale land acquisitions (Matrix, n.d.) and the Murdock Ethnographic Atlas (Murdock 1967), respectively. In the remainder of section, I overview these data and the methodologies I used to assemble them.

2.1 Land titling: DHS and LSMS

The lack of administrative data on land titling has hampered the ability of scholars to study the subject. Datasets are often private or difficult to access. Importantly, they

are also not comparable across countries—what is included in one country may not be included in another country. I sidestep this problem using survey data.

Specifically, I combine data from two large scale data collection efforts. The first is the United States Agency for International Development (USAID)'s Demographic and Health Surveys (DHS) project. The DHS project collects comparable data on developing countries around the world. While the project is largely health focused, DHS also asks about households' participation in agriculture and their landholdings. Among other questions, the DHS asks "do you have a title deed or other government recognized document for any land you own?" Importantly DHS only asks this question in a random subsample of men within surveyed households.

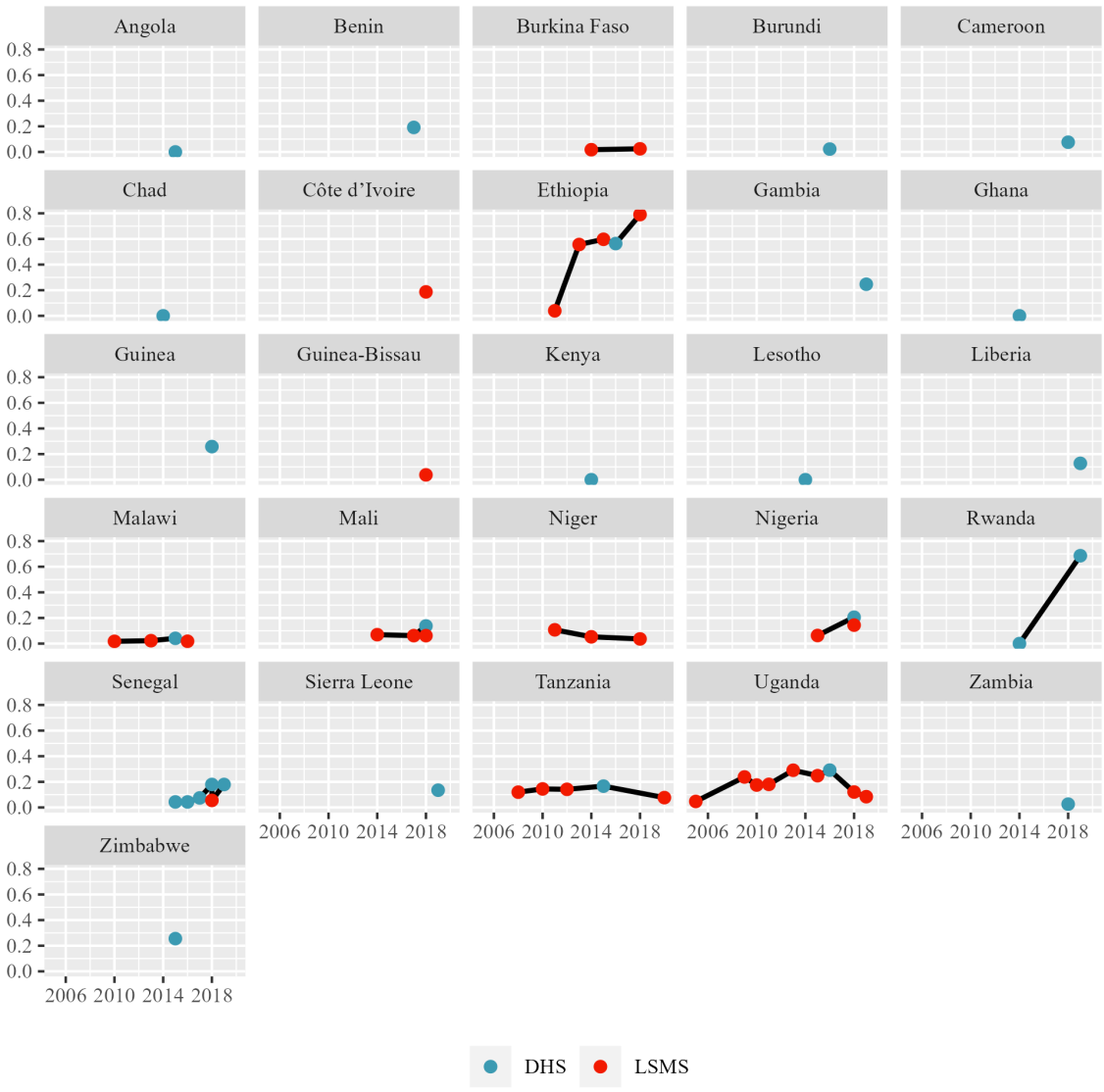
The second large scale data collection effort is the World Bank's Living Standards Measurement survey. Like the DHS, this survey is a large scale effort to collect comparable data across the developing world. Unlike the DHS, the LSMS has a greater focus on agriculture and economic conditions than on health. The LSMS contains a parcel-level roster of agricultural land and asks "[d]oes your household currently have a title or ownership document for this parcel."[8]

The main outcome variable for this paper is a binary indicator for whether a household posesses at least one title for their agricultural land. Importantly, both sets of surveys include similar questions for whether a household posesses a title for their dwelling. This latter variable can serve as an important placebo if we think that agricultural land values will not affect demand for titling houses.[9]

[8] While the DHS uses one standardized protocol across different countries, the LSMS protocols differ substantially across countries. Variable names, values of outcomes, etc. all differe across countries. These differences set practical limits on the number of additional analyses which can be carried out.

[9] An important note is that the outcome variables are not identical across the two surveys—while the

Figure 1. Average titling rates by country and data source over time



Data are from the World Bank's Living Standard Measurement Surveys (LSMS) and USAID's Demographic and Health Surveys (DHS). I subset to rural households.

2.2 Land values

Existing literature suggests that property rights would emerge in response to increased land values. In the context of African land tenure, this characterization suggests that land values would drive demand for land titling.[10] But this untested relationship begs an important question: how does one measure land values?

Land markets in most of Africa are both informal and illegible, which prevents researchers from directly measuring land sales. To overcome these issues, I implement a novel measurement of 'attainable value,' which I construct as the value for which the maximum attainable yield (per hectare) could sell for on the international market. I combine crop suitability data with global commodity prices to obtain these land values at a 10km by 10km grid cell level. Adjusting the underlying parameters of the suitability models allows me to calculate the returns to fertilization based on prevailing crop values.

I use version 4 of the Food and Agriculture Organization (FAO)'s Global Agro Ecological Zone (GAEZ) model to obtain data the 'attainable yield' of different crop types. The model takes into account climate data (from a variety of potential models), soil and terrain data, as well as observed phenology and crop calendars. The attainable yield I use in these analyses are expressed in kilograms per hectare.[11] Attainable yield here differs from "agro-climactic suitability" because the latter do not take into account soil suitability and terrain factors. These data are averaged over the entire 10km by 10km

LSMS protocol asks if any parcel owned by a household is titled, the DHS protocol asks if any man has a title for their land. While the overwhelming majority of parcels are owned by men, these answers could give slightly different numbers. This difference is absorbed by fixed effects in all models.

[10] Land values drive titling by increasing the conflicts over land.

[11] Some crops use other measures (for example, "alfalfa, miscanthus, napier grass, reed canary grass, pasture legumes and grasses the yields are in 10kg dry weight per hectare") but I apply appropriate conversation factors where necessary (Fischer et al. 2021: 129).

grid cell: potential total production is divided by total grid cell area.[12]

Prices come from the IMF's Primary Commodity Price System.[13] The majority of prices are listed as USD per metric ton; I apply an appropriate correction for other prices. The commodities included in these data are: bananas, barley, chickpeas, canola oil, cocoa, coconuts, coffee, cotton, corn, groundnuts, oats, palm oil, rice, rubber, sunflower oil, soybeans, sorghum, sugar, tea, and wheat.[14]

For each crop and grid cell, I multiply the maximum attainable yield (metric tons per hectare) by the commodity prices in a given year (USD/metric ton) to obtain the attainable price (USD/hectare). I then take the maximum of this vector. More formally, the maximum attainable value π_g of grid cell g in year y is defined as:

$$\pi_{g,y} = \max_c (p_{c,y} \cdot s_{c,y,g})$$

where p indicates crop price, s indicates the attainable yield, and observations are indexed by g for grid cell, y for year, and c for crop. These data will measure the maximum attainable value in dollars per hectare for a given 10km by 10km grid cell on a yearly basis.

Of course, the global commodity prices are different from those received by farmers. However, the validity of this measurement requires only that the prices farmers receive are positively correlated with global commodity pricing. In appendix A.2, I show that

[12] These data are based on the RCP4.5 climate projection.

[13] The FAO's producer price database provides more granular estimates of crop prices, but it has too many missing data points to be useful. For example, in our target period it is missing data for cocoa and coffee prices in Cote d'Ivoire—the country's two primary export commodities.

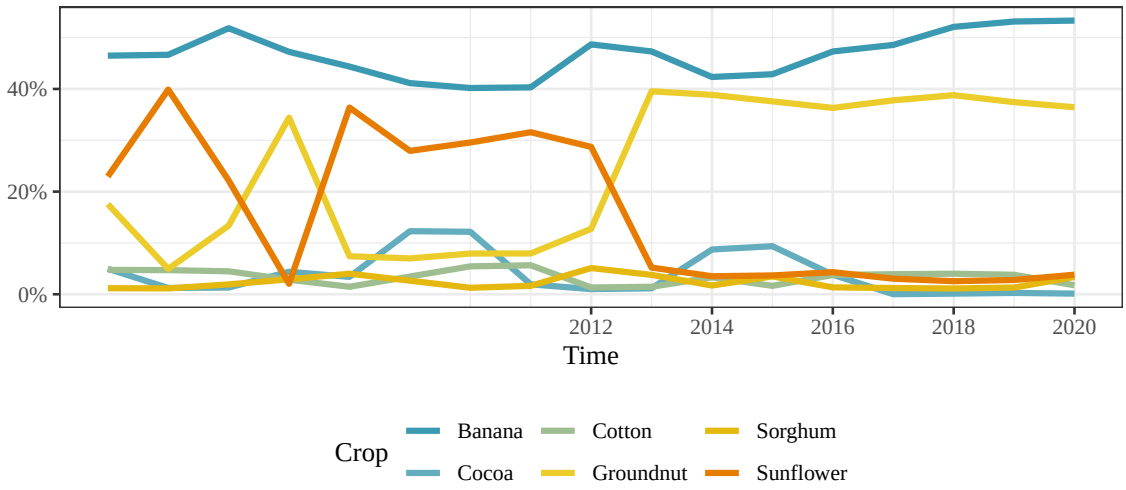
[14] I exclude tomatoes because the commodity price is calculated as the consumer price per kilo in metropolitan France, rather than the price per kilo on the international commodity market.

households respond to this measure by changing their planting patterns. A one percent increase in the average attainable value per hectare of a crop is associated with a 0.13 to 0.159 percentage increase in the amount of land that farmers dedicate to that crop. Similarly, an increase of one percent in the fraction of an administrative area in which a crop is the most profitable is associated with a 0.076-0.080 percent increase in the fraction of land that farmers dedicate to that crop. In other words, farmers appear to be reacting to this land value in a manner consistent with this land value measure capturing the underlying phenomenon.

This metric superficially resembles a Bartik, or shift-share instrumental variables (SSIV), design. A plethora of literature in recent years has enumerated the assumptions through which shift-share instrumental variables identify effects and placed limits on their applicability (Borusyak, Hull, and Jaravel 2022; Goldsmith-Pinkham, Sorkin, and Swift 2020). However, the weighted exposure to common shocks approach I adopt differs from a SSIV in two key ways. First, my measure is not an instrument—attainable yield operationalizes the latent land values directly. Second, the SSIV designs use the weighted exposure to shocks across sectors; the canonical design weights sector-level exposure to Chinese import competition by industry concentration in a given area. In this paper, the land values metric takes the maximum of a series of values (i.e. the highest multiplicative product of crop yield and commodity price) rather than a weighted mean.

Figure 2 shows the percentage of grid cells for which a given crop has the highest attainable value. The figure excludes crops which are the most potentially valuable in less than one percent of grid cells. This excludes a number of important cash crops; coffee, for example, often has high attainable values but only within small areas.

Figure 2. Percentage of grid cells where each crop is most valuable



Note: This figure excludes crops which are the most valuable in less than one percent of grid cells. Data are from the FAO's Global Agro Ecological Zone model and the IMF's Primary Commodity Price System.

These data are an important first check for whether this land value metric appears accurate. All seven listed crops are common across different parts of Africa.. Bananas are consistently the most profitable potential crop. Cotton is a notable cash crop in the Sahel. Sorghum is notable for growing where other crops could not. It is important to note that crops can be consistently profitable without appearing in these time series. These figures suggest that this measure has some face validity for measuring change in agricultural attainable value.

Table 1 shows the descriptive statistics for this land value measure in each year (in constant 2011 USD). These values are roughly similar per year, but we can see some key trends. Values decrease over time. While the maximum value increases most years, the 25th percentile, median, and 75th percentile decrease over time. On their face, these

Table 1. Attainable yield summary statistics by year

Year	Mean	StdDev	Min	25th percentile	Median	75th percentile	Max
2011	2558.2	2072.3	0	433.0	2650.9	4271.5	8526.8
2012	2273.9	1844.5	0	338.6	2386.3	3822.9	7778.0
2013	2469.3	1984.7	0	331.0	2632.4	4160.9	8236.8
2014	2265.4	1849.6	0	271.7	2372.1	3813.3	7511.8
2015	2100.1	1729.5	0	250.3	2190.4	3509.3	7447.4
2016	1958.0	1621.9	0	234.3	2037.5	3254.3	7577.5
2017	2049.1	1703.0	0	250.8	2109.1	3406.0	7950.7
2018	2073.0	1727.6	0	262.3	2121.1	3461.7	8292.6
2019	1881.8	1588.6	0	226.7	1920.9	3102.2	8107.5
2020	1970.7	1660.9	0	231.8	2026.8	3248.2	8531.1

Note: Values are in 1000s of constant 2011 U.S. dollars. Data are from the FAO's Global Agro Ecological Zone model and the IMF's Primary Commodity Price System. These data only cover the countries included in the combined DHS/LSMS dataset.

data confound the standard relationship between land tenure formalization and land values. Land tenure formalization is increasing over time; attainable land values are not. These data are too detailed for visual detail across the continent, but Figure 3 shows this change over time in an example country: Burkina Faso. Overall the trends are the same. Different regions of Burkina Faso see different fluctuations; for example, the Hauts-Bassin regions sees an increase in values around 2012 and 2014. Attainable yields are much lower in the arid far north of the country.

Importantly, these data allow me to not only calculate land values, but to back out the returns to investments in agricultural production. These values provide an important alternative metric of land values. If farmers formalize in order to feel secure in investing in their parcels, then it is important to operationalize the returns to these investments. I calculate these investments in two ways. First, I show the returns to using fertilizer on a given parcel. The data described above present data using a specific GAEZ model which

specifies low levels of fertilizer use. I re-calculate these models using a high fertilizer version as well and use the difference to back out the returns to fertilization, conditional on prevailing commodity values.

Second, I also calculate the returns to planting tree crops, rather than perennial crops. The crucial difference is that tree crops require a high up-front investment, either in purchasing saplings or in waiting for trees to become productive. Coffee trees, for example, take five to seven years to become commercially viable. As a result, tree crops represent a longer-term investment than purchasing fertilizer for the remaining year. Of the 20 crops for which I have price data, I classify bananas, coconuts, cocoa, coffee, rubber, and tea as tree crops.

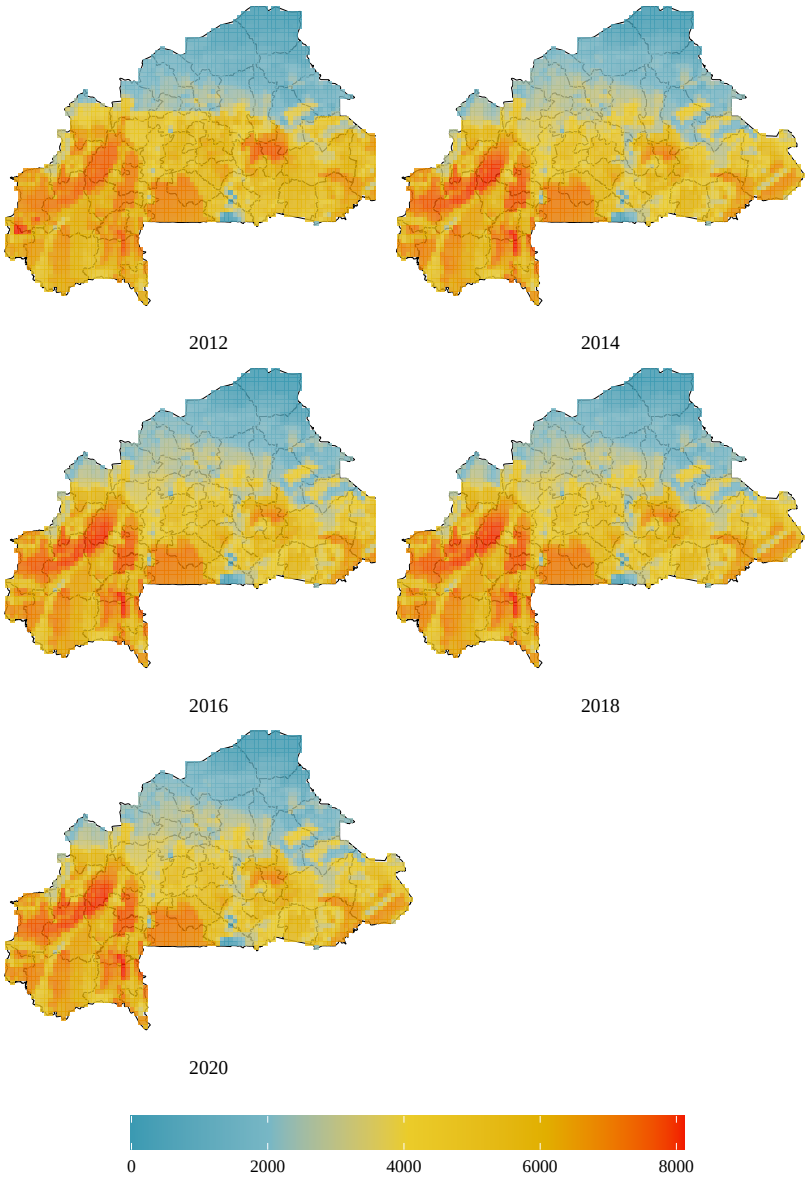
The values based on global commodity reflections are not necessarily an accurate reflection of what farmers actually receive for their crops. However, the critical assumption behind this measurement strategy is that the relationship between global commodity prices and the prices that farmers actually receive remains relatively consistent. One important intervening variable could be the prescence of commodity export boards which create monopsonies for agricultural products. By creating a uniform purchase price for crops, these boards extracted surpluses from rural households and redistributed them to urban households and national governments (Bates 1981). However, such boards largely fell out of fashion with the Washington Consensus and its related reforms.

A second important qualification is that these data assume that rural households choose crops to maximize incomes. Qualitative evidence suggests that farmers are responsive to global prices; Maclean (2010), for example, shares an anecdote of Ghanaian farmers converting to tomato cultivation in response to shifting global prices. On the

other hand, social instutions also constrain crop choices. In parts of Senegal, for example, rice growing is perceived to be men's work while cultivating market gardens of various vegetables is considered women's work (Coen et al. 2019). However, the attainable values and returns to fertilization operationalize the value of land, rather than its actual output. Higher attainable yield would increase the value of the land regardless of whether the farmer actually acts upon changes in potential value. Appendix A.2 also provides quantiative support for this assumption: using a subset of my data, I confirm that households in areas where crop a is more valuable do indeed plant more of crop a. In other words, the elasticity of crop plantings with regards to crop values is positive.

In summary, I use a novel strategy to measure the value of land across sub-Saharan Africa by focusing on the value for which the parcel's attainable yield would sell on the international market. I combine geospatial data on the maximum attainable yield for a variety of crops with global commodity prices to obtain the maximum attainable value at a 10km by 10km grid level across Africa. This approach also allows me to back out returns to fertilization, an important form of agricultural investment.

Figure 3. Attainable agricultural value per hectare in Burkina Faso, 2012-2020

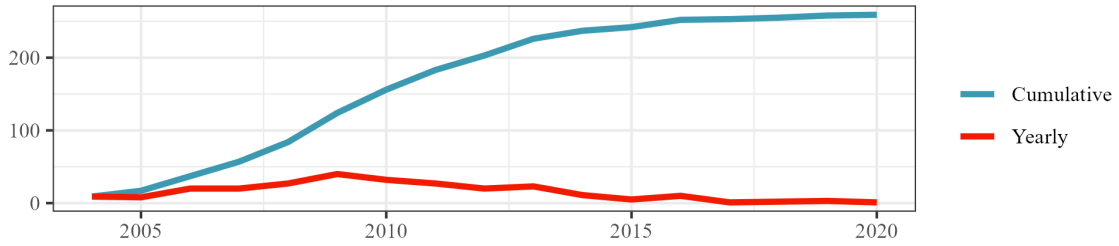


Note: Values are in 1000s of constant 2011 U.S. dollars. Data are from the FAO's Global Agro Ecological Zone model and the IMF's Primary Commodity Price System.

2.3 Large scale land acquisition

I use data from the Land Matrix project to measure the threat to land. The Land Matrix is "independent global land monitoring initiative" which endeavors to collect information on 'Large Scale Land Acquisitions' (LSLAs), or land grabs, across the developing world. It defines LSLAs as "any intended, concluded, or failed attempt to acquire land through purchase, lease, or concession for agricultural production, timber extraction, carbon trading, renewable energy production, industry, mining, oil and gas extraction, conservation, tourism, and land speculation in low- and middle-income countries." It captures the sectors of the intended deals, as well as whether the LSLA was concluded, whether it has not progressed past the 'intended' state, or whether the deal failed.

Figure 4. Large scale land acqusitions over time in sub-Saharan Africa



Note: Data are from the Land Matrix dataset; this count only includes LSLAs marked as 'concluded.' This figure only includes deals in sub-Saharan Africa.

A typical LSLA is the case of Senhuile, an agrobusiness company which operates in the Saint-Louis region of the Senegal river valley. Owned by multinational investors, the company holds a lease for 20,000 hectares on which it grows sweet potatoes to convert to ethanol (Word 2014). The company displaced as many as 40 villages, largely of the Peulh ethnic minority. Negotiations for the lease were conducted only with elites in Dakar,

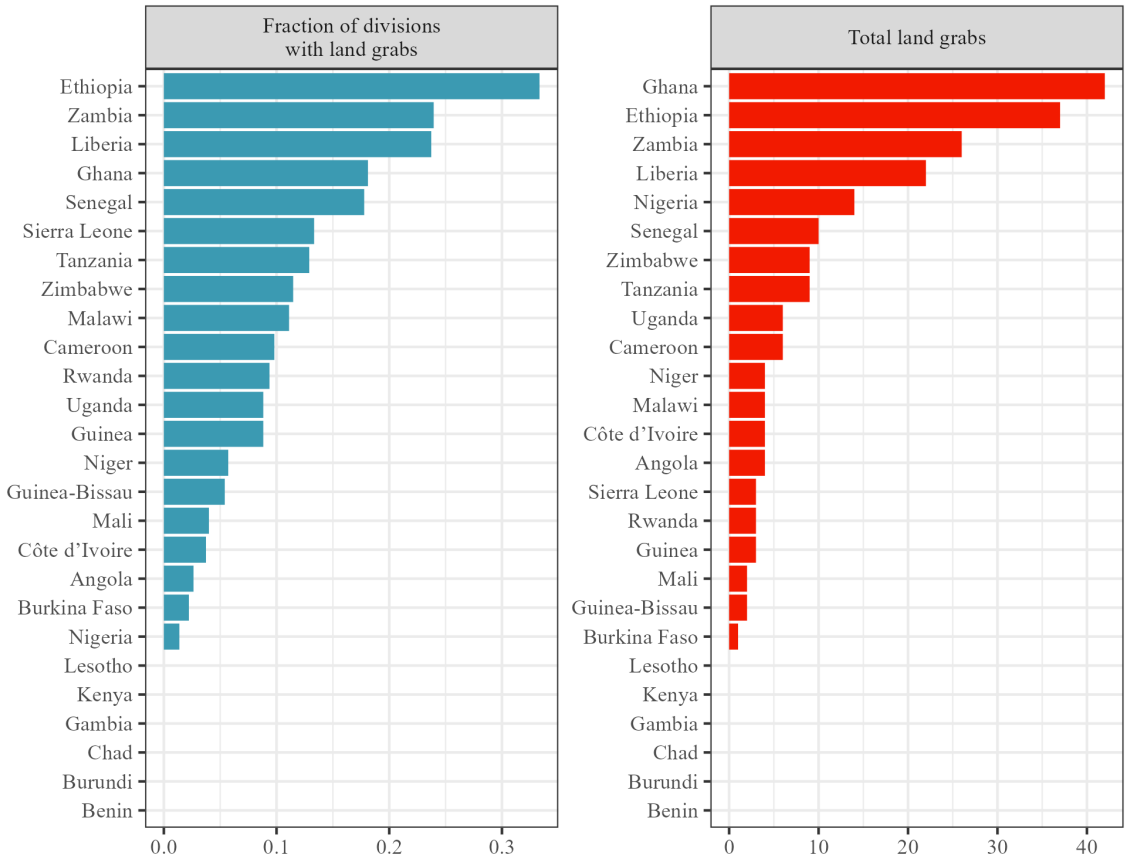
not with local leaders. Two successive Senegalese presidents, Abdoulaye Wade and Macky Sall, appear to have intervened personally on behalf of Senhuile. The Senhuile deal also led to a number of violent incidents, including a young pastoralist stricking a Senhuile worker with a sword and a seperate incident at the Fanaye rural council during which two people were killed (Koopman 2012: 660). The Senhuile case illustrates two key features of LSLAs: they are often damaging to the interests of rural smallholders, and they are generally negotiated with minimal local input.

The Land Matrix are likely a noisy measure of true land grabs. Land grabs are inherently difficult to measure. As the Senhuile case illustrates, land grabs are generally unpopular, which means that they are rarely publicized. Perpetrators may even take measures to conceal their participation in land grabs. To combat the lack of systematic data, the Land Matrix uses a variety of sources, including country partners, civil society stakeholders, and crowdsourcing. All included land deals are documented by at least two sources. This approach means that—while we can be fairly confident that all LSLAs in the database exist—the Land Matrix is likely an undercount of land grabs. Nevertheless, it remains the most comprehensive source of data on land acqusitions in the Global South.

Figure 4 shows both the number of new LSLAs per year and the cumulative totals of LSLAs across sub-Saharan Africa. Specifically, it shows a peak in 2009 of approximately 50 land grabs per year. However, this figure masks differences across countries. Figure 5 shows both the fraction of first level administrative divisions in which a land grab took place, and the total count of land grabs. This figure illustrates that land grabs are a problem across sub-Saharan Africa. In both columns, the five countries with the

highest incidence of LSLAs are Ethiopia, Zambia, Ghana, Liberia, and Senegal. That these countries are scattered around the continent shows the scope of land grabs across Africa.

Figure 5. Large scale land acqusitions by country



Note: Data are from the Land Matrix dataset; this count only includes LSLAs marked as 'concluded.' This figure only includes deals in sub-Saharan Africa.

Throughout the subsequent regressions, I use the cumulative count of land deals within a first-level administrative division as the specific operationalization of threats to land. I do this for two reasons. First, while LSLAs do often displace many households,

the affected households are generally a small fraction of a regions population. The greatest effect of these land grabs will be to increase the perceived risk of losing land. A household may think that if a LSLA happened to other households, it may happen to their household. As such, any LSLAs within a household's region are likely to increase the perceived risk of losing land. Second, using the cumulative total, as opposed to the yearly count of LSLAs, should better capture the overall threat environment to land.

2.4 Strength of customary institutions

To measure the strength of customary institutions, I use data from the Murdock Ethnographic Atlas (Murdock 1967). The Murdock Ethnographic Atlas is a common reference for differences among pre-colonial institutions. The Murdock dataset includes 89 variables on 802 different ethnic groups around the world, of which 239 are located in sub-Saharan Africa.

These data are meant to operationalize the extent to which customary institutions are able to enforce property rights in the absence of formal documentation. If your village chief is able to protect property rights, the marginal returns to titling are likely to be lower. The specific variable from the Murdock dataset through which I operationalize my measure is the society's level of hierarchy:

> the number of jurisdictional levels... [which] indicates the number of levels up to and including the local community and the second those transcending the local community. Thus 20 represents the theoretical minimum, e.g., independent nuclear or polygynous families and autonoomous bands or villages, whereas 44 represents the theoretical maximum, e.g., nuclear families, extended families, clan-barrios, villages, parishes, districts, provinces, and a complex state. (Murdock 1967: 10).

In other words, this variable represents the number of administrative levels in precolonial societies. Acephalous societies, such as the independent villages of northern Ghana, would rank at the lowest level (Nathan 2022). Highly structured societies, with multiple layers of hierarchical institutions, would score higher. In Senegal, for example, the Imamate of Fouta Toto posessed a ruling council, regional chiefs, and village chiefs. Such a precolonial kingdom ranks highly on the Murdock scale.

Importantly, these data rank precolonial institutions—not the strength of current customary institutions. However, a variety of literature explores the legacies and persistence of precolonial institutions with regards to contemporary outcomes. Honig (2022*a*: 11), for example, notes that

> Customary institutions with hierarchical legacies trace their roots to powerful precolonial states with hierarchical authority structures that withstood the colonial conquest. These institutions had a distinctly high organizational capacity at the end of the nineteenth century. This contrasts with the customary institutions with nonhierarchical legacies in [Senegal and Zambia], which either had hierarchical structures that were razed during colonial territorial conquest or, more commonly, never endogenously developed hierarchy... the diverse origins of these institutions set them on different trajectories, producing variation in the contemporary strength of customary institutions within each country.

Similarly, Wilfahrt (2018) notes how the overlap of precolonial institutions and contemporary state organs affects local redistributive politics in Senegal.

While the enforcement of property rights is not the same thing as institutional hierarchy, two factors suggest that more hierarchical institutions would be better able to enforce property rights.[15] First, customary elites who are situated within these hierar-

[15] Alternatively, customary institutions with multiple loci of control may provide for greater security of

chical institutions are more empowered to enforce their decrees. Within weakly hierarchical society, customary elites may not have the political capital to enforce judegements (Boone 2003). Second, the nature of hierarchical institutions increases the accountability of customary elites. In an acephalous village, an unfair ruling by the chief could go unchallanged; where there are customary elites above the village chief, there is a chance for appeal. This accountability may prevent chiefs from making decisions based on favoritism or their own interests (Honig 2022*a*).

The Murdock data have the strong advantage of being comprehenseive, as well as comparable across states. The Murdock data cover 239 distinct precolonial institutions across the African continent. The geospatial coverage of these data permits me to extract the fraction of an administrative division which is covered by a strong precolonial institution for all observations.[16] For the specifications using EA centerpoints to merge geospatial data, I use a binary indicator for whether the precolonial institutions intersect a 20km radius around the EA.

Another measurement strategy could be to adapt Afrobarometer data, which includes a variety of measures of confidence and reliance on customary institutions. However, I do not use Afrobarometer for two reasons. First, the Afrobarometer data are not available at a sufficiently granular level: the available data include only the respondent's first administrative division. In contrast, my outcome data on uptake of formal

property rights. In some African societies, village chiefs co-exist with customary elites with a land-specific mandate (Lund 2008). Called earthpriests in Ghana, or chefs de terre more generally, these customary elites may lead to better governance through the seperation of powers. I intend to explore this connection in future research.

[16] My results are largely identical when replacing the fraction of an administrative division covered by a hierarchical precolonial institution with a binary indicator for whether at least some of the administrative division was covered by a hierarchical precolonial institution. This result helps assuage concerns related to the inexactitude of precolonial borders.

property rights are available at the second level administrative division, and my primary measure of land values is available at a 10km by 10km grid across sub-Saharan Africa. More importantly, however, even within the first level administrative regions, the sample size is relatively small. For example, the Saint-Louis region of Senegal encompasses both the old colonial capital of French West Africa and much of the fertile rice-growing Senegal River Valley. According to Senegal's 2023 census, its population is 1.2 million. Afrobarometer sampled 80 respondents from this area for its eight wave; the 2019 round of DHS data collected 336 responses. While these samples are randomly selected, and thus provide an unbiased average result, the overlap is just too small for statistical analysis—any correlations are as likely to be noise as they are to be signal.

3 Descriptive evidence

One contribution of this paper is to provide an overview of titling patterns across sub-Saharan Africa. Previous studies of land formalization, whether qualitative or quantitative, have largely been confined to single contexts due to data limitations. This paper provides the first large-scale evidence of how land titles are distributed across sub-Saharan Africa. Figure 6 shows that distribution, including some unexpected hotspots of formal land titles. The Tombouctou region of Mali, for example, has the country's highest rate of titling. Similarly, the Fouta Djallon highlands of Guinea, a bastion of customary authority, has surprisingly high levels of titling.

Next I show descriptive evidence of the relationship between the factors I enumerate above and the fraction of landholding households with at least one formal title. Figure 7 shows the relationship between my three measures of land value and the fraction of households posessing at least one formal land title. Each point represents averages of titling rates and land values across a second level administrative division. I subset to only the most recent set of LSMS and DHS data, to avoid over-emphasis on regions which have been surveyed multiple times.

Despite the prevailing literature, figure 7 shows no significant relationship between either measure of land value and titling rates. Both the total attainable yield per hectare and the per hectare returns to fertilization appear to have no strong relationship with land titling. If anything, there is a slightly negative relationship: areas with high attainable yield or returns to fertilization have slightly lower rates of land formalization. Similarly, the returns to tree crops are weakly positive, but the relationship is not definitive.

Figure 8 shows how these variables correlate with the land grabs measured via Land Matrix data. On the lefthand panel, the vertical axis measures the total attainable yield per hectare in 1000s of constant 2011 USD. On the righthand panel, the horizontal axis measures the fraction of households with at least one title. Both horizontal axes measure the total count of cumulative land grabs. These figures show that both land titling and land values are positively correlated with the cumulative frequency of land grabs, at least when aggregated to the second level administrative division.

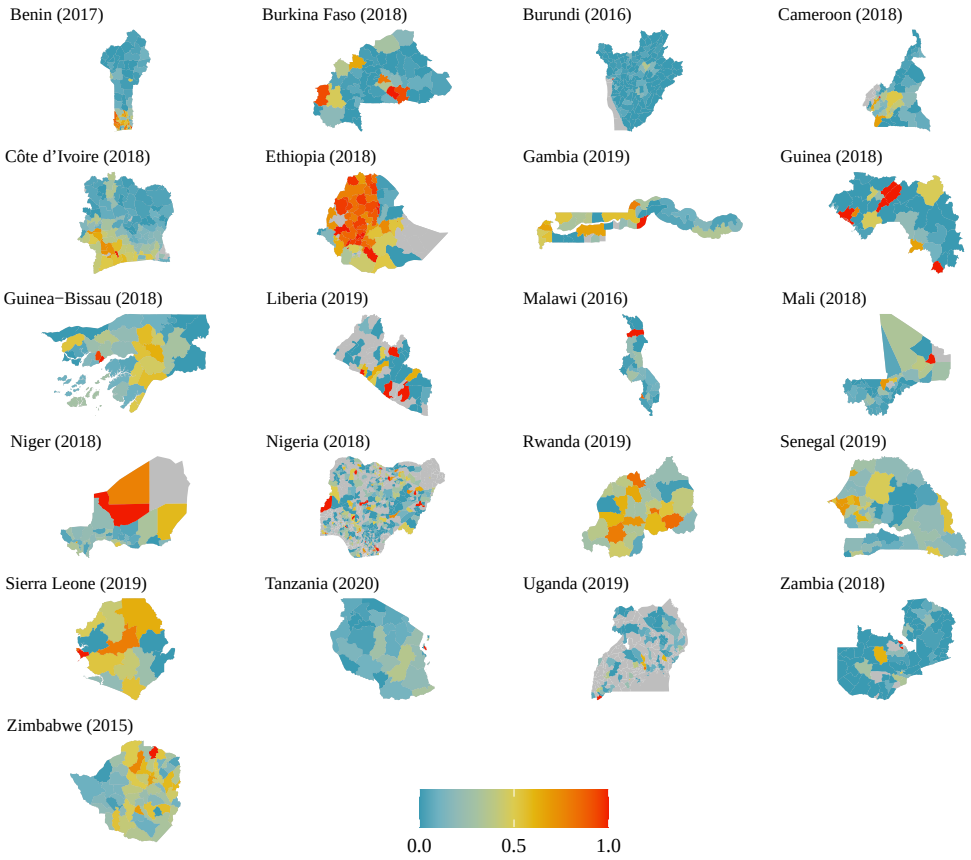
This correlation is consistent with the underlying theories enumerated above. It makes sense that land grabs are positively correlated with agricultural yield—the majority of land grabs are agricultural, so agribusinesses are likely to target areas which are valuable for agricultural production. With regards to titling, households in regions where more land grabs have taken place are likely more conscious of the risk of expropriation, leading them to title more. This correlation is consistent with my theoretical model. However, in both of these cases, results appear to be driven by a small number of outlier regons in which land grabs took place. In 99 percent of regions, zero land grabs took place.

Finally, we can examine several other variables which may correlate with these data, but which are not available at a level of sufficient disaggregation to be used in subsequent regression analysis. Figure 9 shows how country-level averages of titling rates covary with GDP per capita, the World Banks's human development index, average trust in customary chiefs, and average trust in the country's local government. The latter two variables are extracted from Wave 8 of the Afrobarometer survey. Each trust value is demeaned at the respondent level by removing the average level of all other trust

variables. This figure shows very slight correlations with GDP per capita and the human capital index, but stronger correlations between confidence in customary chiefs and confidence in local government.

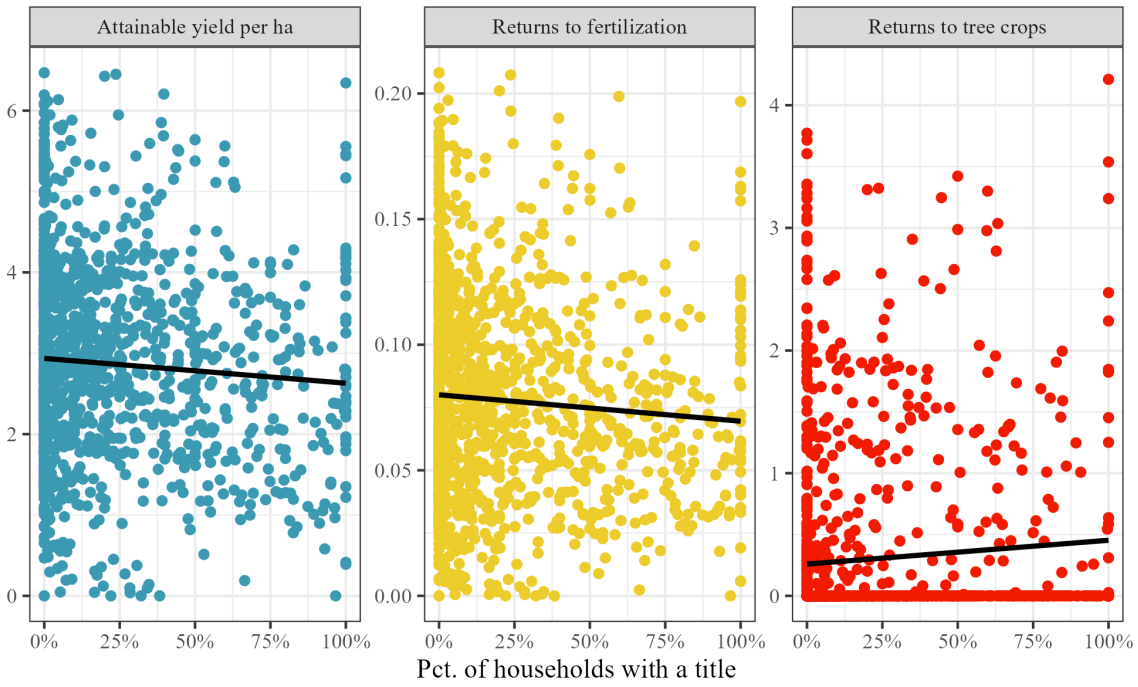
The figures in this section call into questions some of the variables that conventional theory predicts would covary with land titling. Neither the total attainable value per hectare nor the returns to fertilization appear positively correlated with land titling at the second level administrative division level. Land grabs, i.e. the level of threat to land, do appear slightly correlated with titling rates at the administrative division level, but the effect is mostly driven by a small fraction of second level administrative divisions with multiple land grabs. With further aggregation to the country level, neither GDP per capita nor the human capital index are strongly correlated with titling rates, but confidence in various political institutions do seem correlated. In the subsequent section, I explore these relationships further using a series of regressions.

Figure 6. Relationship between land value variables and the fraction of landholding households with a formal title



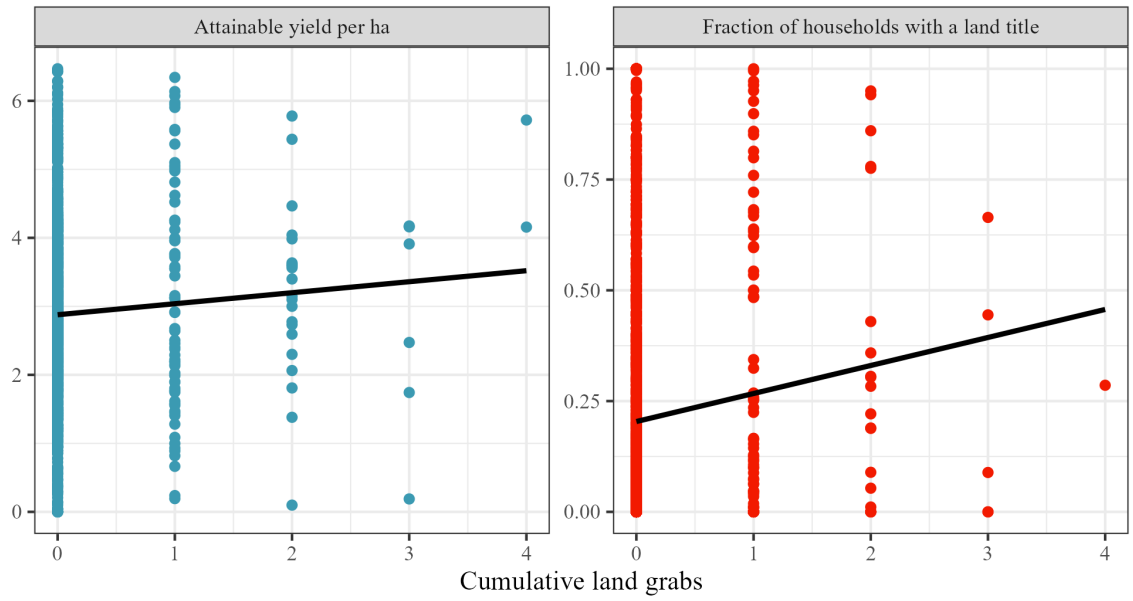
Note: This figure shows the percentage of households that have at least one title for their agricultural parcels. Data are from the most recent round of DHS or LSMS; shapefiles are from the GADM database. All averages use DHS or LSMS survey weights; weights are uniform when not provided.

Figure 7. Relationship between land value variables and the fraction of landholding households with a formal title



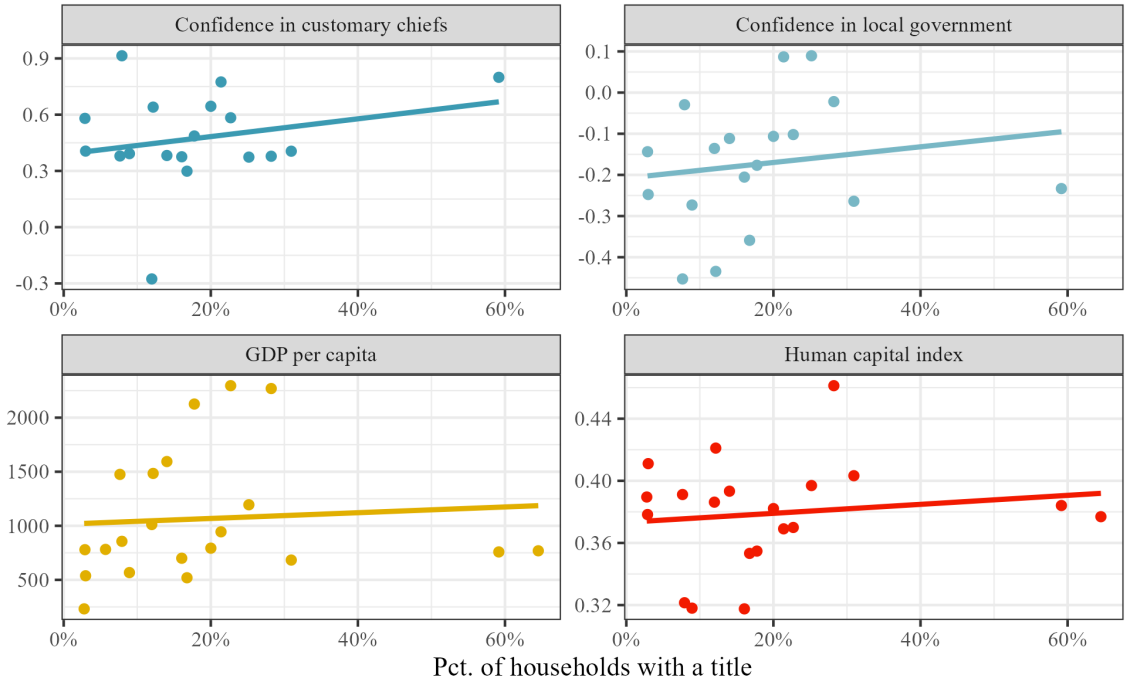
Note: Values are in 1000s of constant 2011 U.S. dollars. Value data are from the FAO's Global Agro Ecological Zone model and the IMF's Primary Commodity Price System. The returns to titling are calculated as the increase in attainable value calculations when adjusting for higher rates of fertilization. Titling data are from the latest rounds DHS and LSMS programs, as applicable.

Figure 8. Cumulative land grabs, the fraction of households with a land title, and attainable yield per hectare



Note: Cumulative land grabs (horizontal axis) are measured using concluded deals from the Land Matrix dataset. The vertical axis for attainable yield per hectare is 1000s of constant 2011 U.S. dollars, using data are from the FAO's Global Agro Ecological Zone model and the IMF's Primary Commodity Price System. The fraction of households with a land title are from the latest rounds DHS and LSMS programs. Points represent 2nd level administrative division averages. This figure excludes two outliers: the Mishrak Shewa zone of Ethiopia, with seven land grabs, and the Iringa district of Tanzania, with five. The line of best fit is calculated using OLS.

Figure 9. Relationship between land value variables and the fraction of landholding households with a formal title



Note: This figure shows country-level average titling rates. Titling data are from the most recent round of DHS or LSMS. Confidence data come from round eight of the Afrobarometer survey. GDP per capita and human capital index data come from the World Bank and are calculated in 2019 and 2017 respectively. Titling rates and Afrobarometer data use survey weights; weights are uniform when not provided. Lines of best fit are calculated via OLS.

4 Cross-national regressions

My central hypotheses concern the relationship between posessing a formal land title and a variety of economic variables. I particularly focus on the value of land, for which I introduce a novel geospatial measure of the maximum attainable value per hectare and the returns to agricultural investment. I also include the threat to land, measured by the cumulative count of large scale land grabs. Because customary institutions may also protect property rights effectively, I also include a series of interactions with a measure of the hierarchy in precolonial institutions.[17]

For all of the regressions below, the outcome variable is a binary indicator for whether a household posesses a land title. All regressions are estimated using ordinary least squares with fixed effects at the country-wave level (i.e. each survey wave has its own intercept). I also include a set of demographic controls, including the household head's eduction level, sex, age, marital status, and whether the household is urban or rural. My geographic controls include the geographic area and population density of the second level administrative region, as well as the interaction of those two variables. These tables take two different approaches to associating the land value variables with my survey outcomes: linking via the second level administrative division, linking via the center point of the enumeration area. All land value data are lagged by one year: I regress the outcome variable in year t on land value data in year $t-1$.

The primary variables of interest on the right hand side of the equation relate to land values. As I describe above, I measure land values by interacting the attainable yield per hectare for a variety of different agricultural products with their commodity prices on

[17] The un-interacted measure of customary institutions is absorbed by fixed effects.

the global market and taking the maximum. We can think of this estimation strategy as a form of weighted exposure to external shocks: the crop prices are the shocks, and the total attainable yields per hectare are the weights. One potential threat to inference in this case is that observations' weights (i.e. their crop suitabilities) are likely not entirely exogenous to land titling. Soil quality may have other causal pathways to land titling rates; for example, Baldwin and Ricart-Huguet (2023) show that land quality affects the power of traditional leaders. In such cases, a non-random exposure to common shocks research design can lead to omitted variable bias (Borusyak and Hull 2020). When not otherwise controlled for by fixed effects, I include the average shock across all years for observation i to control for this bias.[18]

I cluster all standard errors at the second level administrative division level, because this is the level at which the land value treatment is "assigned." Because my data are spatial in nature, there is also a risk that my standard errors are aflicted by spatial autocorrelaion—what affects unit i may also be affected by i's neighbors. However, across my regressions, the Conley standard errors are consistently smaller than the clustered errors, so I present the latter.

First, I take the average of the agricultural variables at the level of the second level administrative division. The advantage of this approach is that the administrative divisions are available for all of my data points.[19] The disadvantage of this approach is

[18] Boryusak and Hull (2020) note that the distribution of shocks must be stationary over time for a time-invariant counterfactual shock to eliminate this source of omitted variable bias. After controlling for inflation, the distribution of maximum possible values per observation is indeed stationary.

[19] The mean second level administrative division is 4909 square kilometers. The 25th percentile is 459 square kilometers and the 75th percentile is 4352 square kilometers. The distribution of administrative division size has a long tail largely because of the size of arid regions. The largest second level administrative division in my data is the Tombouctou region of Mali, followed by the Borkou region of Chad. Other large administrative divisions have similarly arid climates and low population densities.

Table 2. Potential value of output and the likelihood of a household formalizing

	(1)	(2)	(3)	(4)	(5)	(6)
Max value	0.015	0.016	−0.010	−0.034	−0.001	−0.006
	(0.028)	(0.029)	(0.012)	(0.033)	(0.030)	(0.030)
Difference (trees)			0.103***	0.098***		
			(0.016)	(0.018)		
Difference (fertilizer)					0.343	0.442
					(0.579)	(0.565)
Land grabs	−0.004	−0.003	−0.003	−0.002	−0.004	−0.004
	(0.005)	(0.006)	(0.005)	(0.006)	(0.005)	(0.006)
Country/Wave Fixed Effects	X	X	X	X	X	X
Demographic Controls		X		X		X
Geographic Controls		X		X		X
Num.Obs.	166 012	152 909	166 012	152 909	166 012	152 909
R2	0.232	0.237	0.238	0.243	0.232	0.237

Note:
The dependent variable of this model is a binary indicator for whether the household posesses a title. The unit of analysis is the household. Land value data vary at the second level administrative divison, with the exception of Cote d'Ivoire (third level) and Malawi (first level). Data are from the DHS and LSMS projects. Country and year two-way clustered standard errors are displayed in parentheses.

that second-level administrative divisisions can be relatively large amounts of space.[20] Tables 2 and 3 display the results of these regressions. Table 2 shows the maximum attainable value, the difference between fertilized and unfertilized maximum attainable values, and the marginal increase in value from planting tree crops. Table 2 shows a positive relationship between the returns to tree crops and the fraction of households with a title, but no other statistically significant relations. The confidence intervals for both measures of the maximum attainable values per hectare, as well as those for land grabs, are relatively precisely estimated null results.

I further investigate these relationships in table 3, which interacts these variables with the indicator for the fraction of a second level administrative division in which a hierarchical customary institution existed in the precolonial period. These results tell a

[20]There were some inconsistencies in how the LSMS data were assigned administrative divisions. As a result, data in Côte d'Ivoire are geolocated to the 3rd level administrative division (communes) and data in Malawi are geolocated to the 1st level administrative divsion (districts).

Table 3. Potential value of output, hierarchical pre-colonial institutions, and the likelihood of posessing a land title

	(1)	(2)	(3)	(4)	(5)	(6)
Max value	0.019	0.019	0.006	0.006	−0.034*	−0.040**
	(0.023)	(0.024)	(0.026)	(0.028)	(0.014)	(0.015)
Max value * Hierarchy	−0.026	−0.028	−0.025	−0.027	0.044	0.049
	(0.025)	(0.026)	(0.024)	(0.025)	(0.044)	(0.046)
Difference (trees)			0.110*	0.103*		
			(0.045)	(0.043)		
Difference (trees)* Hierarchy			−0.011	−0.011		
			(0.054)	(0.054)		
Difference (fert.)					1.505**	1.694***
					(0.543)	(0.398)
Difference (fert.)* Hierarchy					−1.999	−2.192
					(1.199)	(1.181)
Land grabs	−0.021**	−0.021**	−0.017*	−0.016*	−0.024***	−0.025***
	(0.008)	(0.008)	(0.007)	(0.007)	(0.006)	(0.006)
Land grabs * Hierarchy	0.031	0.032	0.023	0.023	0.037*	0.039*
	(0.022)	(0.022)	(0.020)	(0.022)	(0.018)	(0.018)
Country/Wave Fixed Effects	X	X	X	X	X	X
Demographic Controls		X		X		X
Geographic Controls		X		X		X
Num.Obs.	166 012	152 909	166 012	152 909	166 012	152 909
R^2	0.233	0.238	0.240	0.244	0.234	0.240

Note: The dependent variable of this model is a binary indicator for whether the household posesses a title. The unit of analysis is the household. Land value data vary at the second level administrative divison, with the exception of Cote d'Ivoire (third level) and Malawi (first level). Data are from the DHS and LSMS projects. Country and year two-way clustered standard errors are displayed in parentheses.

striking story, particularly when compared to table 2. In this case, the returns to fertilization are strongly predictive of the fraction of titling rates, as are the returns to tree crops. In this table, a one standard deviation increase in the extent to difference in maximum attainable value between a fertilized hectare and a non-fertilized hectare is associated with approximately a seven percentage point increase in the fraction of households who posess a formal land title, against a baseline of approximately 16.8 percent of households. However, this effect is weaker or nonexistent in areas of high customary authority. While the coefficient is not statistically significant on the interaction between the percentage of an administrative region covered by hierarchical institutions and the returns to fertilization, the effect size is nevertheless large and negative. Curiously, land grabs become statistically significant in this prediction—but in the opposite direction than predicted. Each cumulative land grab is associated with approximately three percent lower rates of titling. The interaction between land grabs and the presence of hierarchical institutions is only statistically significant in one specification, but consistently trends in the opposite direction.

Together, these tables present interesting results. In contrast to the first order prediction of economic theories which center 'endogenous property rights,' households in administrative divisions with higher attainable yields are no more likely to posess a land title; in certain specifications, they are less likely to posess a land title. However, in regions without strong customary institutions, households appear to formalize in response to changes in the returns to agricultural investment.

Tables 4 and 5 repeat these regressions, but on the subset of LSMS and DHS data which include the latitude and longitude of enumeration areas (EAs). EAs are the lowest

Table 4. Potential value of output and the likelihood of a household formalizing (EA-level)

	(1)	(2)	(3)	(4)	(5)	(6)
Max value	−0.042	−0.038			−0.020	−0.016
	(0.039)	(0.039)			(0.037)	(0.038)
Difference (trees)			0.026*	0.022		
			(0.011)	(0.010)		
Difference (fertilizer)					−0.603	−0.599
					(1.076)	(1.149)
Land grabs	−0.004	0.000	−0.003	0.001		0.000
	(0.006)	(0.006)	(0.006)	(0.006)		(0.006)
Country/Wave Fixed Effects	X	X	X	X	X	X
Demographic Controls		X		X		X
Geographic Controls		X		X		X
Num.Obs.	83 488	74 659	83 488	74 659	83 488	74 659
R2	0.274	0.273	0.277	0.274	0.274	0.273

Note: The dependent variable of this model is a binary indicator for whether the household posesses a title. The unit of analysis is the household. Land values are calculated as the average of a 20 kilometer circle around the enumeration area. Data are from the DHS and LSMS projects. Region and year two-way clustered standard errors are displayed in parentheses.

level at which households are sampled for the DHS and LSMS data; they correspond to villages or wards. In these specifications, I calculate the average value of land value data within a 20 kilometer radius circle around each EA's center point.[21] The advantage of this strategy to link my data sources is that it yields much more precise measures of the value of a given household's land. The downside is that a fraction of surveys do not contain enumeration area coordinates. Specifically, Burkina Faso, Côte d'Ivoire, Malawi, Mali, and Uganda drop out of this sample.

Table 4 shows the relationship between the land variables measured at the EA level and the fraction of households posessing at least one title for their agricultural parcels. Once again, households with a higher potential return to planting tree crops are more

[21]The actual enumeration area coordinates usually have 1-5 kilometers of random noise introduced to add anonymity, with one percent of enumeration areas having up to 10 kilometers of spatial noise added. Because the size of this noise is less (and sometimes much less) than the size of my radii, I do not consider this spatial noise further).

Table 5. Potential value of output, hierarchical pre-colonial institutions, and the likelihood of posessing a land title (EA-level)

	(1)	(2)	(3)	(4)	(5)	(6)
Max value	−0.054	−0.052	−0.031	−0.030	−0.032	−0.037
	(0.037)	(0.036)	(0.033)	(0.034)	(0.031)	(0.028)
Max value * Hierarchy	0.016	0.017	0.013	0.009	0.015	0.022
	(0.016)	(0.016)	(0.015)	(0.014)	(0.053)	(0.050)
Difference (trees)			0.027*	0.029*		
			(0.011)	(0.011)		
Difference (trees)* Hierarchy			−0.002	−0.011		
			(0.010)	(0.009)		
Difference (fert.)					−0.573	−0.394
					(0.502)	(0.551)
Difference (fert.)* Hierarchy					0.022	−0.181
					(1.265)	(1.272)
Land grabs	0.000	0.001	0.002	0.003	−0.001	0.001
	(0.012)	(0.012)	(0.012)	(0.012)	(0.010)	(0.011)
Land grabs * Hierarchy	−0.005	−0.001	−0.006	−0.002	−0.004	0.001
	(0.016)	(0.018)	(0.015)	(0.017)	(0.012)	(0.014)
Country/Wave Fixed Effects	X	X	X	X	X	X
Demographic Controls		X		X		X
Geographic Controls		X		X		X
Num.Obs.	83 476	74 647	83 476	74 647	83 476	74 647
R2	0.277	0.276	0.279	0.278	0.277	0.277

Note: The dependent variable of this model is a binary indicator for whether the household posesses a title. The unit of analysis is the household. Land values and exposure to precolonial hierarchy are calculated as the average of a 20 kilometer circle around the enumeration area. Data are from the DHS and LSMS projects. Region and year two-way clustered standard errors are displayed in parentheses.

likely to posess a land title, depending on the specification. The remaining estimates are precisely estiated nulls: the confidence intervals are clustered tightly around zero. Table 5 tells a similar story. Even in specifications where variables aggregated at the administrative division level were statistically significant, these variables do not have a significant effect on the rates of land titling when measured in more precise catchment areas.[22]

This section used a variety of modeling strategies to examine whether changes in land values and the frequency of large scale land grabs affect the likelihood of posessing a land title. I estimated the equations in two different specifications: at the household level with land values calculated at the second level administrative division and at the household level with land values calculated in a 20 kilometer radius around the enumeration area center point. In appendix A.3, I re-estimate these equations with all variables aggregated to the second level administrative division. The results are consistent. The returns to fertilization are positively associated with the likelihood of posessing at least one title for agricultural land—but only when controlling for the strength of precolonial customary institutions. Where strong precolonial institutions do not exist, households with higher returns to fertilization are ***more*** likely to posess a land title. Where strong customary institutions exist, households do not title more in response to increases in returns to fertilization.

Contrary to conventional economic theory, both land values and land grabs are unrelated to titling rates in most specifications. In table 3, where these variables are sig-

[22] Rather than calculating the fraction of an administrative division which is covered by a hierarchical precolonial institution, in these specifications I include a binary indicator for whether any part of the 20 kilometer circle around the EA centerpoint intersects a precolonial institution. I do this to avoid any noise associated with imperfectly defined boundaries.

nificant, their effects are in the opposite direction of that predicted by the literature I enumerate above.

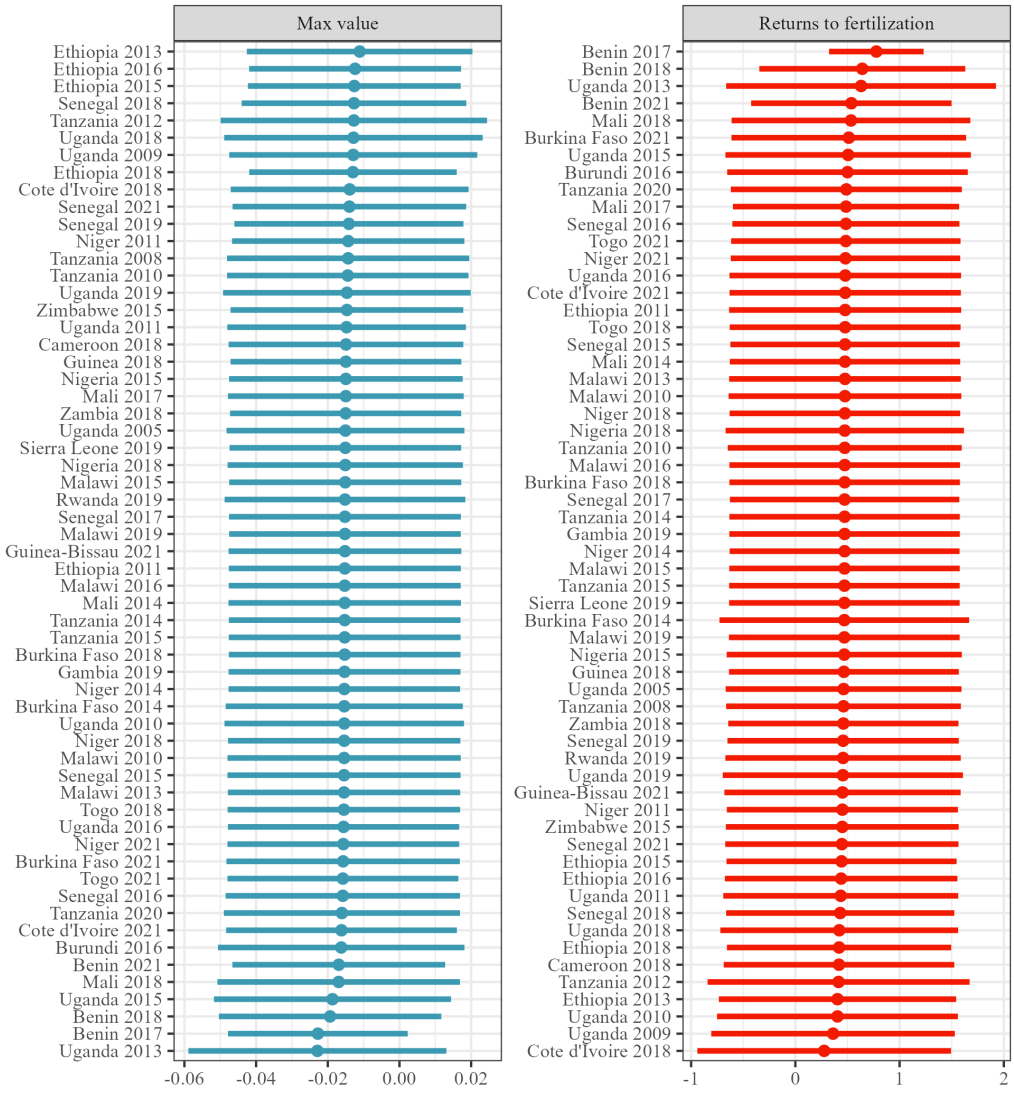
5 Robustness Checks

In this section, I present results from a series of robustness checks. I first re-run my various regressions while removing individual country-wave pairs. This strategy can identify whether my results are being driven by outlier countries or years. Second, I re-estimate these equations with a placebo outcome. In lieu of using whether or not a household has a title for their agricultural parcels, I examine whether a household has a title for their dwelling.

I run both of these robustness checks on the primary specification of the paper—calculating the land variables by taking the average of the second level administrative division. Because all the DHS and LSMS surveys contain at least this much geographic detail, this allows me to include the maximum number of observations. In the appendix, I replicate these robustness checks using both enumeration-area averages for the land variables and while using the second level administration division as the unit of observation, rather than the respondent. Results are largely similar.

Figure 10 shows how the coefficients of my main specifications change when excluding individual country-year survey waves. In other words, for each country-year wave, I remove these data from the main data, re-run the regressions while excluding the country year, and save the results. This exercise shows the extent to which my results are dependent on specific countries or years, which may be outliers. While these coefficients become statistically significant in a handful of equations, the results are overall very consistent. My results do not appear to be driven by any particulary country or wave of the LSMS and DHS data.

Figure 10. Coefficients estimates for removing country-year waves



Data are from the World Bank's Living Standard Measurement Surveys (LSMS) and USAID's Demographic and Health Surveys (DHS). The vertical exis denotes the country-year wave of the DHS or LSMS survey

Next I examine a placebo outcome: whether a household posesses a formal title for their dwelling, rather than for their agricultural land. Having a title for one's house

Table 6. Potential value of output and the likelihood of a household posessing a title for their house (placebo outcome)

	(1)	(2)	(3)	(4)	(5)	(6)
Max value	0.008	−0.012	0.002	−0.011	0.023	−0.001
	(0.011)	(0.011)	(0.012)	(0.012)	(0.031)	(0.029)
Max value * Hierarchy	0.000	0.015	0.002	0.012	0.004	0.015
	(0.014)	(0.013)	(0.016)	(0.014)	(0.040)	(0.031)
Difference (trees)			0.033	−0.004		
			(0.030)	(0.028)		
Difference (trees)* Hierarchy			−0.012	0.011		
			(0.031)	(0.030)		
Difference (fert.)					−0.458	−0.315
					(0.820)	(0.729)
Difference (fert.)* Hierarchy					−0.096	−0.014
					(1.032)	(0.809)
Land grabs	−0.006	−0.007	−0.005	−0.007	−0.006	−0.007
	(0.013)	(0.012)	(0.013)	(0.012)	(0.013)	(0.012)
Land grabs * Hierarchy	−0.012	−0.005	−0.014	−0.005	−0.010	−0.004
	(0.012)	(0.014)	(0.013)	(0.015)	(0.012)	(0.014)
Country/Wave Fixed Effects	X	X	X	X	X	X
Demographic Controls		X		X		X
Geographic Controls		X		X		X
Num.Obs.	248 122	222 586	248 122	222 586	248 122	222 586
R_2	0.073	0.109	0.074	0.109	0.074	0.109

Note: The dependent variable of this model is a binary indicator for whether the household posesses a title for their dwelling. The unit of analysis is the household. Land value data vary at the second level administrative divison, with the exception of Cote d'Ivoire (third level) and Malawi (first level). Data are from the DHS and LSMS projects. Country and year two-way clustered standard errors are displayed in parentheses.

should not be affected by my explanatory variables. The attainable value of agricultural parcels should not affect the household's incentives to title their dwelling.[23] Similarly, there is not a clear causal linkage between the returns to agricultural investment and titling one's dwelling.

Table 6 shows no relationship between my explanatory variables and the likelihood that a household posesses a title for their dwelling. Were I to identify a relationship between my explanatory variables and whether a household posesses a title, this associ-

[23] If the binding constraint to titling one's house is the cost of titling, increased value of agricultural production could alleviate this constraint, but this result is not supported by the data.

ation would call into questions my primary results. Because there is not a theory-driven linkage between titling one's house and the explanatory variables, a statistically significant discovery would suggest that my explanatory variables are measuring a different underlying phenomenon than the value of land, the returns to agricultural investment, and the level of risk to land. The null finding in Table 6 helps to increase confidence that my primary measurements accurately capture the theoretical quantities I describe in section 1.

6 Conclusion

Why do only some African farmers pursue land titles? This paper combines multiple waves of survey data to identify broad trends in land titling across sub-Saharan Africa. I create a novel geospatial measure of land values at a 10km by 10k grid on a yearly basis. Specifically, I interact data on the attainable yield of 20 different crops with global agricultural commodity prices. Adjusting the underlying parameters of the crop suitability model also allows me to back out the monetary returns to fertilization, a common form of agricultural investment. Breaking out crops by the level of investment required also allows me to identify the marginal increase in potential agricultural revenues from planting tree crops. I also include data on large scale land acquisitions and precolonial customary institutions.

Across a variety of specifications, households in areas with high returns to agricultural investment are more likely to posess a title for their agricultural parcels. However, this effect only takes place in areas with weaker customary institutions. In areas with

stronger customary institutions, households with higher returns to fertilization are no more likely to posess a formal land title. I do not find any affect for land values. The relationship between large scale land acqusitions and land titling is inconsistent.

These results are consistent with my broader dissertation project, which explores demand-side explanations for the low uptake of formal land titles. Orthodox models of land formalization put forward by development organizations such as the USAID or the Millennium Challenge Corporation focus largely on the supply of land titles (Albertus 2020). However, the poor performance of 'piecemeal' titling requires a pivot to explain the lack of demand for land titles. Supply-side explanations for land titling also struggle to explain the remarkable variation in titling rates across countries, regions, and even villages.

In the rest of my research, I show how local politics conditions the demand for formal property rights. A major component of this theory focuses on how the political legitimacy of customary chiefs plays at least two important roles in land titling. First, chiefs decide whether to support or impede formalization. Formalization benefits chiefs in the short run: they may extract rents through the process (Honig 2022*a*) and they may be seen in a positive light for bringing development goods to their village (Baldwin 2016: 10). However, customary land is an ongoing source of legitimacy for chiefs. By bringing conflicts to the village chief, parties to a dispute implicitly recognize the legitimacy of the chief to arbitrate those conflicts. Control over land also allows chiefs to sanction villagers who do not comply in other sectors. Informal land provides an ongoing source of legitimacy for the chief; formalizing titles provides a short-term boost at the cost of constricting the long-term source of legitimacy. Second, chiefly legitimacy affects the

perceived benefits of formalization. Formalization secures land from expropriation and makes farmers more likely to receive the returns of any investment they make (Goldstein and Udry 2008). Where chiefly authority is high, households will perceive their land rights to be sufficiently secure already. This dynamic suggests that the marginal benefit of formalizing land is decreasing in chiefly authority.

The other variable I center in my broader dissertation theory is the role of confidence in local government institutions. The lack of reliable and comparable measurements of confidence in local government precludes me from incorporating this variable in my analyses, though figure 9 provides some purely suggestive evidence that confidence in local government is positively correlated with titling rates.

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Appendices

Table of Contents

A1 Further Robustness Checks

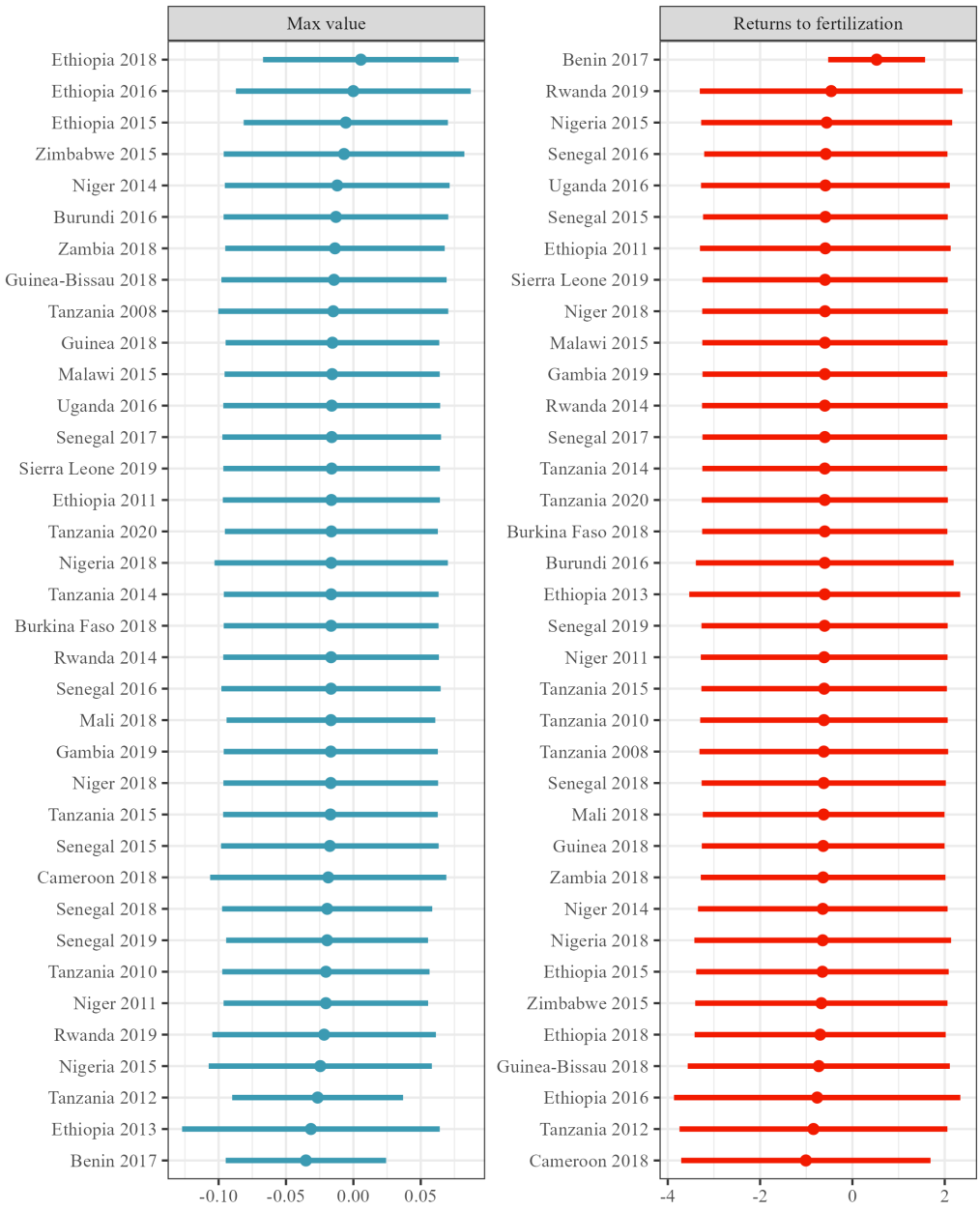
In the above paper, I display robustness checks for the first specification of my primary regressions. This specification calculated the land variables using the average over the entire second level administrative division in which a respondent is located. The advantage of this approach is that the second level administrator is the lowest common denominator vis-à-vis georeferencing the DHS and LSMS data, so every data point has an associated second level administrative division. On the other hand, some of these administrative divisions are relatively large (especially in arid regions such as the Sahel), and so they may not accurately capture the changing values of a respondents' land. I include these robustness checks for the two other specifications below.

A1.1 EA-level Robustness Checks

Figure 2 shows the results from one by one excluding country-waves from these regressions. Specifically, it shows coefficient estimates and confidence intervals for the maximum value variable and the returns to fertilization, when not interacting with the indicators for whether an EA intersects a strong customary institution. The figure tells a compelling story: there are no country-waves for which the estimate is statistically significant. The 2017 LSMS wave in Benin appears to be an outlier: when removing those entries from the survey, the coefficient on returns to fertilization jumps to 0.59. However, this jump is insufficient to make these results statistically significant.

Second, table A1 replicates table 4, but with a different outcome variable. Here, we replace whether a household posesses a title for their land with whether the household

Figure 1. Coefficients estimates for removing country-year waves



Data are from the World Bank's Living Standard Measurement Surveys (LSMS) and USAID's Demographic and Health Surveys (DHS). The vertical exis denotes the country-year wave of the DHS or LSMS survey

Table A1. Potential value of output and the likelihood of a household posessing a title for their house (placebo outcome)

	(1)	(2)	(3)	(4)	(5)	(6)
Max value	−0.035	−0.029			−0.027	−0.047
	(0.079)	(0.062)			(0.069)	(0.061)
Max fertilized value			−0.034	−0.025		
			(0.077)	(0.059)		
Difference					−0.094	0.439
					(0.667)	(0.288)
Land grabs	−0.016	−0.006	−0.016	−0.006		−0.007
	(0.008)	(0.004)	(0.008)	(0.004)		(0.004)
Country/Wave Fixed Effects	X	X	X	X	X	X
Demographic Controls		X		X		X
Geographic Controls		X		X		X
Num.Obs.	130 849	114 086	130 849	114 086	130 849	114 086
R2	0.066	0.101	0.066	0.101	0.066	0.102

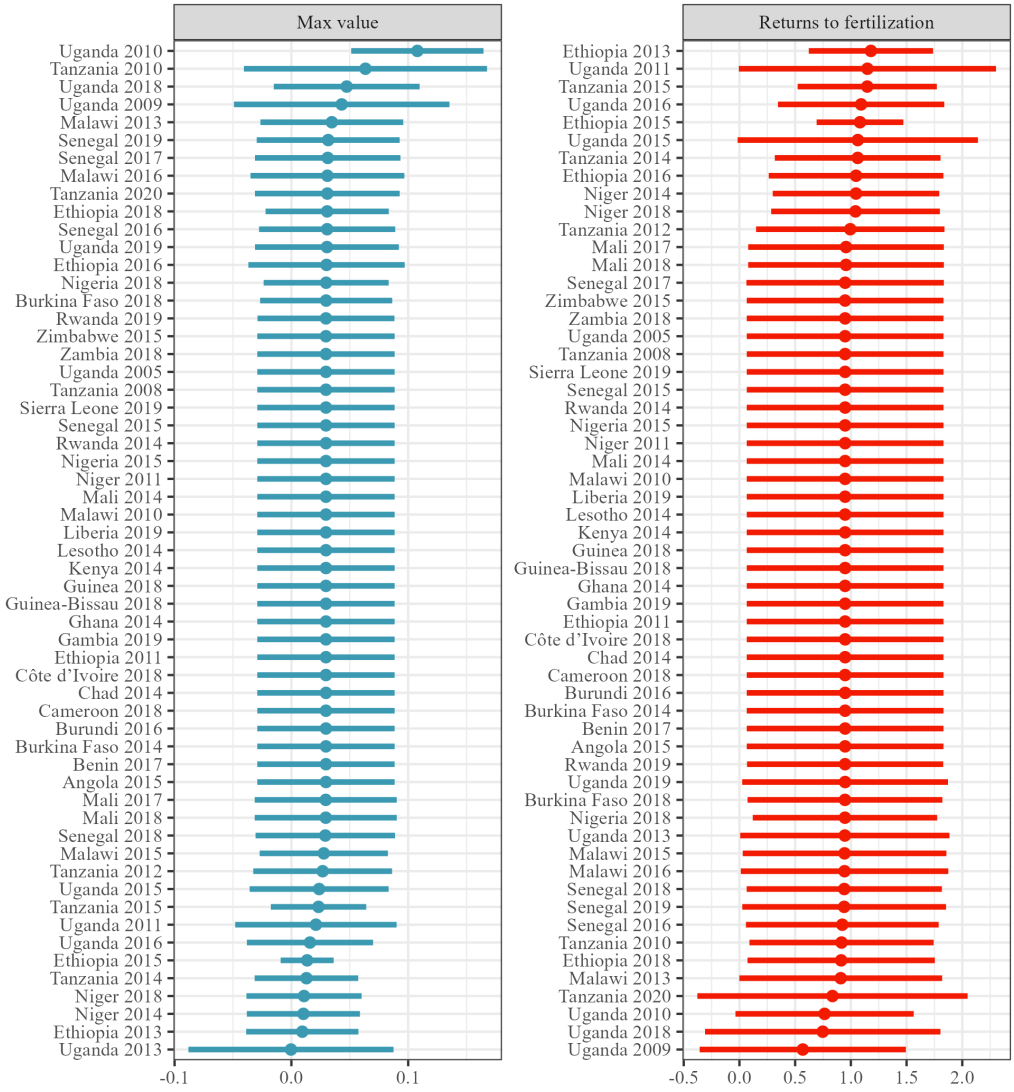
Note: The dependent variable of this model is a binary indicator for whether the household posesses a title. The unit of analysis is the household. Land value data vary at the second level administrative divison, with the exception of Cote d'Ivoire (third level) and Malawi (first level). Data are from the DHS and LSMS projects. Region and year two-way clustered standard errors are displayed in parentheses.

posesses a title for their dwelling. The result is a set of null results—even more precisely estimated nulls than table 5. The exception is that land grabs are statistically significant in one column—but occassional significance is to be expected when testing a number of different coefficients. In other words, these economic variables do not predict whether a household has a title for their dwelling any more than they predict whether a household has a title for their agricultural parcels.

A1.2 Robustness checks with administrative division as unit of observation

I then repeat these robustness checks after aggregating these data to the second level administrative division. As above, the results are largely consistent with other specifi-

Figure 2. Coefficients estimates for removing country-year waves in repeated cross section



Data are from the World Bank's Living Standard Measurement Surveys (LSMS) and USAID's Demographic and Health Surveys (DHS). The vertical exis denotes the country-year wave of the DHS or LSMS survey

Table A2. Potential value of output, hierarchical pre-colonial institutions, and the likelihood of posessing a house title (repeated cross-section placebo outcome)

	(1)	(2)	(3)	(4)
Max value	0.064	0.043	0.031	−0.101
	(0.113)	(0.186)	(0.117)	(0.229)
Max value * Hierarchy			0.059	0.344
			(0.062)	(0.178)
Difference		0.599		3.818
		(2.994)		(3.502)
Land grabs	0.019***	0.019**	0.069	0.082*
	(0.002)	(0.006)	(0.042)	(0.041)
Land grabs * Hierarchy			−0.069	−0.093
			(0.048)	(0.051)
Num.Obs.	2684	2684	2684	2684
Adm2 Fixed Effects	X	X	X	X
NA	NA	NA	NA	NA
Year fixed effects	X	X	X	X
R2	0.885	0.885	0.886	0.890

Note: The dependent variable of this model is the fraction of households with a title for their dwelling (a placebo outcome). The unit of analysis is the second administrative division, except for Cote d'Ivoire (third level) and Malawi (first level). Land values and exposure to pre-colonial hierarchy are calculated at this level. Data are from the DHS and LSMS projects. Country and year two-way clustered standard errors are displayed in parentheses.

cations. While removing country-years, the results do not shift. However, when estimating these equations without the 2010 LSMS data collection in Uganda results in a positive and statistically significant coefficient on the maximum attainable value variable. However, considering that this effect appears only in one specification, this is not unexpected.

Tables A.2 and A.3 replicate above specifications, but using the likelihood that a household posesses a title for their dwelling as a placebo outcome. Interestingly, in these cases, land grabs appear to be somewhat related to the likelihood that a household has a title for their dwelling. When aggregating to the admnistrative division, households in areas with a higher cumulative count of land grabs are more likely to have a title for their

Table A2. Potential value of output, hierarchical pre-colonial institutions, and the likelihood of posessing a house title (repeated cross-section)

	(1)	(2)	(3)	(4)
Pct change	−0.304	−0.553	−0.267	−0.770
	(0.500)	(0.796)	(0.422)	(0.909)
Pct change * Hierarchy			−0.085	1.205
			(0.338)	(1.103)
Difference		0.191		0.545
		(0.295)		(0.721)
Difference * Hierarchy				−1.330
				(1.410)
Land grabs	−0.018	−0.016	0.035	0.051
	(0.030)	(0.032)	(0.051)	(0.062)
Land grabs * Hierarchy			−0.088*	−0.116*
			(0.043)	(0.058)
Adm2 Fixed Effects	X	X	X	X
Year fixed effects	X	X	X	X
Num.Obs.	692	692	692	692
R2	0.764	0.765	0.764	0.770

Note: The dependent variable of this model is the fraction of households with a title for their dwelling (a placebo outcome). The unit of analysis is the second administrative division, except for Cote d'Ivoire (third level) and Malawi (first level). Land values and exposure to precolonial hierarchy are calculated at this level. Data are from the DHS and LSMS projects. Conley standard errors are displayed in parentheses, calculated using a 50 kilometer cutoff and a uniform kernel.

household. Table A.3 shows these same outcomes, but estimated in levels. Now, the outcome variable is the percent increase (or decrease) in land titling, and the explanatory variables are the percent change in the land value variables or the count of new land grabs. Interestingly, the interaction between hierarchical customary institutions and count of new land grabs is negative and significant.

A2 Elasticity

The primary contribution of this paper is to show that land titling in sub-Saharan Africa is not responsive to land values alone. For the land value to be valid, the value needs to affect other economic behaviors that one would suppose to be associated with land values. In this section, I specifically examine whether farmers in areas where crop a has a higher attainable value actually plant more of crop a. In other words, I calculate the elasticity of crop plantings with regards to the attainable value of the crop. For this strategy to measure land values to be reasonable, I would exect a positive association: farmers plant more of crop i where it is more profitable to do so.

I calculate these numbers using a subset of the LSMS data. This set of surveys, called the ***Enquêtes Harmonisé sur les Conditions de Vie es Ménages***, was sponsored by ECOWAS, the Economic Community of West African States. These surveys took place in Benin, Burkina Faso, Côte d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal, and Togo in both 2018 and 2021. This subset specifically is useful because the harmonized surveys use identical variable coding, which allows cross-national analysis beyond the level of simple variables such as whether a household posesses a title.[24] Importantly, these data cover a variety of state capacities, land regimes, and climactic zones.

For each household in this sample, I first calculate the household's overall landholdings. I then calculate the fraction of those landholdings dedicated to a crop. The resulting data uses the household-crop as its unit of observation. For example, one ob-

[24] More specifically, because LSMS surveys (apart from the EHCVM) are collected by national statistics agencies, variable definitions change. There is no equivalent to the DHS recode files, in which large amounts of variables can be easily combined across countries. Using the EHCVM data removes this challanges and renders data analysis more feasible.

servation would be the fraction of household i's land on which cocoa is grown, another observation would be the fraction of household i's land on which sorghum is grown, and so on. To avoid inflating my sample size without meaningful variation, I only include crops which are grown in the given country. For instance, I do not include cotton in Côte d'Ivoire, where it is rarely grown, but do include it in Mali and Niger, where it is a major cash crop.

Table A2 shows the relationship between the attainable value per hectare of a given crop (calculated across the 2nd level administrative division) and the fraction of households' landholdings planted with that crop. Columns 1 and 2 are untransformed; because this relationship can be thought of as an elasticity, I also include columns 3 and 4, which log-transform both the explanatory and outcome variables. The results are strong and statistically significant. For the elasticity regressions in particular, a one percent increase in the attainable value of a crop leads to a 0.130-0.159 percent increase in the fraction of land farmers dedicate to that crop.

Table A2 shows similar results, but with a different explanatory value. Using my land value measure, I back out the percentage of grid cells in a given administrative area where crop i is the most potentially valuable. This strategy provides an alternative measure: if crop i increases in value, it may still not be the most profitable crop, and so changes to the price of crop i may not be picked up in this paper's primary regressions. In contrast, the percentage of an area where crop i is most profitable is invariant to shifts in prices of other crops, unless that price moves above the threshold to where it has a higher attainable value than crop i.

In Table A2, the results are similar to those of Table A2. For a one percent increase

Table A2. Households grow more of a crop when its attainable value per hectare is higher

	(1)	(2)	(3)	(4)
Total value of crop	0.044***	0.047***		
	(0.006)	(0.006)		
log(Total value of crop)			0.130***	0.159***
			(0.017)	(0.020)
Country/Crop Fixed Effects	X	X	X	X
Demographic Controls		X		X
Num.Obs.	392 786	368 394	392 786	368 394
R2	0.348	0.346	0.365	0.369

Note: The dependent variable in these models is the fraction of a household's agricultural land where a crop is the principal planting. The independent variable measures the total attainable value for this crop. Observations are at the household-crop level; the data include all crops which are grown in the respondent's country at least once. All regressions include country-crop fixed effects; standard errors are clustered at the second-level administrative division.

Table A2. Households grow more of a crop in areas where it is the most valuable potential crop

	(1)	(2)	(3)	(4)
Total value of crop	0.030*	0.033*		
	(0.013)	(0.014)		
log(Total value of crop)			0.080***	0.076***
			(0.021)	(0.020)
Country/Crop Fixed Effects	X	X	X	X
Demographic Controls		X		X
Num.Obs.	392 786	368 394	392 786	368 394
R2	0.339	0.336	0.358	0.361

Note: The dependent variable in these models is the fraction of a household's agricultural land where a crop is the principal planting. The independent variable measures the fraction of grid cells within the second level administrative division where a given crop is most profitable. Observations are at the household-crop level; the data include all crops which are grown in the respondent's country at least once. All regressions include country-crop fixed effects; standard errors are clustered at the second-level administrative division.

in the fraction of an administrative region where crop i has the highest attainable value, the fraction of households' land on which they grow crop i increases by 0.076-0.080.

Taken together, these results suggest that my measure of land values is indeed capturing the underlying agricultural conditions which could drive land titling. Farmers make planting decisions in ways consistent with the measure of land values. Where the attainable value of that crop is higher, farmers are more likely to plant it.

Table A2. Potential value of output, hierarchical pre-colonial institutions, and the likelihood of posessing a land title (repeated cross-section)

	(1)	(2)	(3)	(4)
Max value	0.000	−0.053	0.030	−0.060
	(0.076)	(0.074)	(0.098)	(0.106)
Max value * Hierarchy			−0.049	0.039
			(0.052)	(0.096)
Difference		1.323		2.357**
		(0.748)		(0.910)
Difference * Hierarchy				−2.367
				(1.631)
Land grabs	−0.020	−0.020	−0.142	−0.135
	(0.054)	(0.053)	(0.104)	(0.101)
Land grabs * Hierarchy			0.201	0.189
			(0.134)	(0.131)
Adm2 Fixed Effects	X	X	X	X
Year fixed effects	X	X	X	X
Num.Obs.	3738	3738	3738	3738
R2	0.782	0.783	0.783	0.786

Note: The dependent variable of this model is the fraction of land-owning households with a title for their land. The unit of analysis is the second administrative division, except for Cote d'Ivoire (third level) and Malawi (first level). Land values and exposure to precolonial hierarchy are calculated at this level. Data are from the DHS and LSMS projects. Region and year two-way clustered standard errors are displayed in parentheses.

A3 Repeated cross-section estimates

Finally, tables A2 and A2 re-estimate these equations with the second level administrative division as the unit of observation. All observations use the mean rate of titling at the second level administrative divisions. In table A2, the returns to fertilization is statistically significant: an increase of one standard deviation in the returns to fertilization is associated with a twelve percent increase in the expected fraction of households with a formal land title. This is an increase of approximately 75 percent over the baseline titling rate of 17.7 percent. In other words, these results are both statistically and substantively significant. However, the coefficient on the interaction between returns to fertilization

and strong customary institutions is negative and large. As in other specification, these results suggest that households are titling in response to the returns to fertilization only in areas that lack strong customary institutions. This figure shows no statistically significant effect of land values or land grabs on the fraction of households with a formal land title.

Finally, table A2 estimates the relationship between these land variables and titling rates in differences. In other words, this table models the effect of changes in rates of land titling using changes in the value of land, the returns to fertilization, and new land grabs. The results are qualitatively similar to table A2: the returns to fertilization are a statistically significant predictor of the rates of titling. A one standard deviation increase in the returns to fertilization is associated with a 0.04 percentage shift in the increase of titling rates between time t and time $t+1$, against a baseline of 0.058. These results are almost entirely canceled out in areas with strong customary institutions.

Table A2. Potential value of output, hierarchical pre-colonial institutions, and the likelihood of posessing a land title (repeated cross-section, in differences)

	(1)	(2)	(3)	(4)
Change in value	0.039*	0.007	0.069*	0.017
	(0.019)	(0.040)	(0.033)	(0.053)
Change in value * Hierarchy			−0.054*	−0.006
			(0.027)	(0.035)
Change in difference		0.760		1.182**
		(0.423)		(0.427)
Change in difference * Hierarchy				−1.074**
				(0.376)
Land grabs	−0.027	−0.029	−0.020	−0.034
	(0.030)	(0.034)	(0.014)	(0.059)
Land grabs * Hierarchy			−0.005	0.015
			(0.080)	(0.089)
Adm2 Fixed Effects	X	X	X	X
Year fixed effects	X	X	X	X
Num.Obs.	1689	1689	1689	1689
R2	0.601	0.603	0.604	0.607

Note: The dependent variable of this model is the fraction of land-owning households with a title for their land. The unit of analysis is the second administrative division, except for Cote d'Ivoire (third level) and Malawi (first level). Land values and exposure to precolonial hierarchy are calculated at this level. Data are from the DHS and LSMS projects. Country and year two-way clustered standard errors are displayed in parentheses.