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Impacts of large-scale land acquisitions on smallholder agriculture and livelihoods in Tanzania

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E-mail: jasullivan@arizona.edu**Keywords:** large-scale land acquisitions, livelihoods, smallholder agriculture, causal inference, mechanismsSupplementary material for this article is available [online](#)Original content from this work may be used under the terms of the [Creative Commons Attribution 4.0 licence](#).

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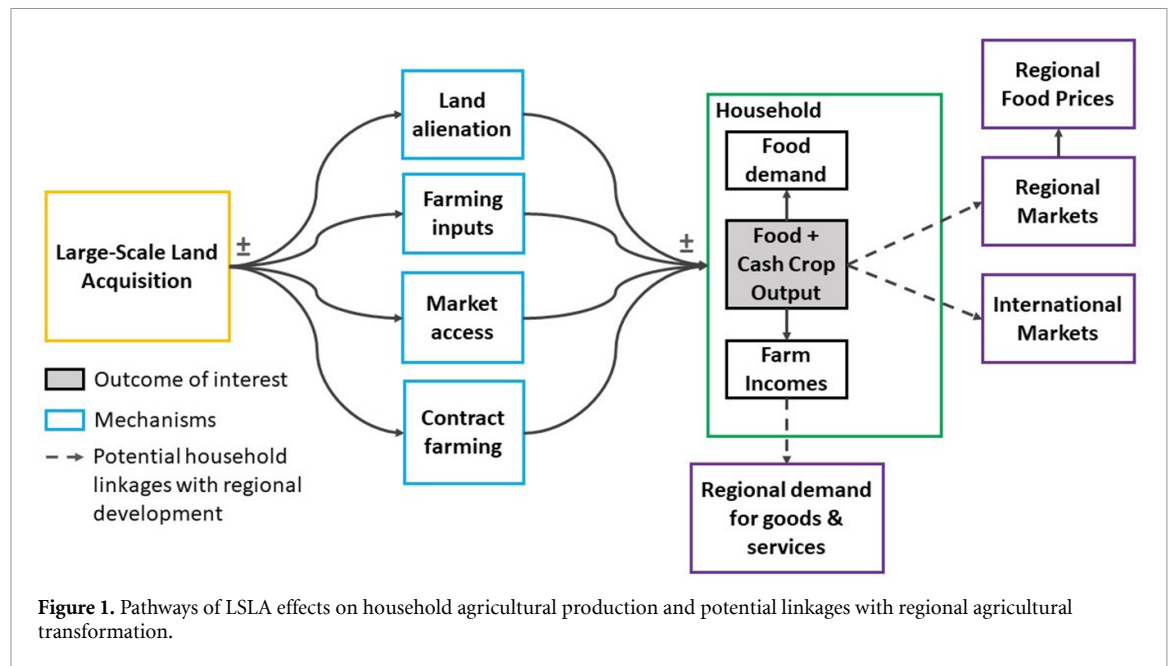
Abstract

Improving agricultural productivity is a foundational sustainability challenge in the 21st century. Large-scale land acquisitions (LSLAs) have important effects on both well-being and the environment in the Global South. Their impacts on agricultural productivity and subsequent effects on farm incomes, food-security and the distribution of these outcomes across households remain under-investigated. In particular, prior studies do not sufficiently attend to the mechanistic nature of changes in household agricultural practices that affect LSLA outcomes. To address these challenges, we use a novel household dataset and a quasi-experimental design to estimate household-level changes in agricultural productivity and other LSLA outcomes in Tanzania. We use causal mediation analysis to assess how four common mechanisms—contract farming, land loss, market access and technology adoption around LSLAs—influence agricultural productivity. We find that households near LSLAs exhibit 20.2% (95% CI: 3.1%–37.3%) higher agricultural productivity, primarily due to increased crop prices and farmer selection of high-value crops. Importantly, the direction and magnitude of effect sizes associated with the different mechanisms vary. The presence of contract farming explains 18.1% (95% CI: 0.56%, 47%) of the effect size in agricultural productivity, whereas land loss reduces agricultural productivity by 26.8% (95% CI: –71.3%, –4.0%). Market access and technology adoption explain little to no portion of the effect size on agricultural productivity. Despite higher agricultural productivity mediated by contract farming, we do not find increased household incomes or food security. Plausible explanations include limited market access, higher crop prices restricting food access and elite capture of contract farming concentrating income effects to a few households. Our results stand in contrast to assumptions that technological spillovers occur through LSLAs and are the principal drivers of LSLA-induced agricultural transformation. We find instead that access to contract farming and high-value crops lead to greater agricultural productivity, but also that benefits related to these mechanisms are unequally distributed.

1. Introduction

Producing adequate food in response to growing demand is a central sustainability challenge (FAO 2002, Foley *et al* 2005, Godfray *et al* 2010). There is increasing focus on improving crop yields in low productivity agricultural landscapes to meet global

demand, achieve food security, reduce rural poverty and lessen pressure on ecosystems (Foley *et al* 2011, Tilman *et al* 2011, Mueller *et al* 2012). Although often overlooked in discussions about food security, land tenure has undergone a major transition in the 21st century towards greater consolidation of ownership and control by transnational corporations through



large-scale land acquisitions (LSLAs; Agrawal *et al* 2019, Liao *et al* 2020a). Since 2000, an estimated 30 million hectares of land were purchased or leased by foreign investors in places of prevailing yield gaps such as Latin America, sub-Saharan Africa, Asia and eastern Europe (Lay *et al* 2021). Catalyzed by the conjunction of rising food prices in 2008, commodification of land and negative effects of climate change on food supply, LSLAs (sometimes called ‘land grabs’) are replacing traditional forms of agriculture and driving changes in agrarian livelihoods (Borras *et al* 2011, Fairbairn 2020). However, the effects of LSLAs on agricultural productivity, often considered the ‘engine’ of agricultural transformation (Barrett *et al* 2010), continue to be debated (Borras *et al* 2011, Deininger 2011, Deininger and Byerlee 2011).

More than a third of LSLAs occurred in sub-Saharan Africa where yields are 20%–40% of what is attainable for major cereal crops (Mueller *et al* 2012, Ray *et al* 2012). Some argue LSLAs will address low crop yields primarily through modernization of agriculture (Deininger and Byerlee 2011). Mechanisms through which higher productivity benefits can spillover into adjacent farms include agricultural technology, improved market access and wage-labor opportunities (Deininger and Xia 2016, Herrmann 2017, Ali *et al* 2019). LSLAs may also deliver benefits through contract farming, where those who gain control over land (often companies) act as buyers of crops grown by local farmers under contracts specifying price, quantity and other market specifications (Bellemare and Lim 2018, Agrawal *et al* 2019). Outside the context of LSLAs, contract farming programs can improve smallholder farmer incomes and welfare under a variety of contract conditions

(Bellemare 2012, Ton *et al* 2018, Arouna *et al* 2021), although concerns related to unequal access remain (Sulle 2017, Isager *et al* 2018, Martiniello 2021).

Despite evidence that LSLAs can improve rural well-being via access to modern farming practices (Ali *et al* 2019), a growing body of research demonstrates the detrimental social outcomes for nearby populations. A principal effect of LSLAs is the enclosure of livelihood assets, including farmland, forests and water resources (Rulli *et al* 2013, Oberlack *et al* 2016, Davis *et al* 2020). In particular, coercive displacement is common in the wake of LSLAs (Dell’Angelo *et al* 2017) leaving rural families landless or displaced to marginal lands (Zaehring *et al* 2018). Beyond land, LSLAs can spark increased competition over labor thereby increasing labor costs and reducing farm incomes (Hofman *et al* 2019). The combined effects of LSLAs on land and labor can compromise local food security (Rulli and D’Odorico 2014, Müller *et al* 2021) with disproportionate impacts on women (Hajjar *et al* 2019).

No clear consensus emerges from the literature on whether the net effect of LSLAs is to improve or worsen household agricultural production, subsequent effects on incomes and food security and the mechanisms underpinning outcomes. Indeed, the lack of agreement across studies is in part due to the diversity of key mechanisms through which LSLAs affect local populations (figure 1). Global studies find that if LSLAs were to close yield-gaps that the diets of an additional 110–360 million people could be supported (Rulli and D’Odorico 2014). However, observational analyses find that despite expansion and intensification of agriculture driven by LSLAs in sub-Saharan Africa, food security conditions worsened

(Müller *et al* 2021). Global studies of LSLAs are important to detail their scale and impacts but they have been less effective in analyzing variation at the level of LSLAs, households and in identifying causal mechanisms.

At local scales, studies focus on agricultural outcomes and provide insight into how LSLAs influence rural well-being. For example, Deininger and Xia (2016) demonstrated that improved technologies from LSLAs may spillover into and be adopted by nearby populations, however no improvement to crop yields resulted. An alternative study finds that smallholder farm sizes decline, yields are lower and small farmers pay more for labor (Bottazzi *et al* 2018). Overall, there is insufficient evidence in how smallholder agricultural productivity changes as a result of nearby LSLAs or the mechanisms that mediate productivity changes. Similarly few studies examine multiple outcomes—productivity, income and food-security. As a result insights into the nature of agricultural transformations prompted by LSLAs remain unidimensional.

To balance generalization with case-specific inference concerning the relationship between LSLAs, agricultural production and rural well-being, we undertake a multi-site analysis. Our analysis considers the differential impact of LSLAs on agricultural productivity by analyzing the relationship between key LSLA characteristics and household outcomes. We evaluate outcomes using a survey dataset of 705 Tanzanian households, sampled through a quasi-experimental study design. Using a stratified cluster sample, we selected households within villages proximate to LSLAs and households within similar villages not near LSLAs. We first analyze differences in household agricultural productivity between LSLA and non-LSLA households. We then use causal mediation analysis to examine the pathways, including land alienation, technology adoption, improved market access and contract farming, through which effects of LSLAs occur (figure 1; Ferraro and Hanauer 2014a). Finally, we investigate whether improved agricultural productivity generates anticipated benefits of increased farm incomes and food-security. Our study complements the work of both (a) meta-analyses that compare a broad set of LSLA conditions but lack counterfactual analyses (see Oberlack *et al* 2016, Dell'Angelo *et al* 2017) and (b) a growing body of causal inference studies that link LSLAs to numerous socio-ecological outcomes but lack insight into how effects vary across LSLAs (Baumgartner *et al* 2015, Jung *et al* 2019, Müller *et al* 2021). Our study generates careful causal inference-based estimates of the effects of LSLAs on household agricultural productivity and supports these estimates with mechanistic detail of observed outcomes.

2. Methods

2.1. Study area and design

Tanzania is at the confluence of debates on food security, poverty, agricultural development and the role of LSLAs in agricultural transformation (Nolte *et al* 2016). The population of Tanzania is expected to more than double by 2050 based on a medium growth scenario (United Nations 2019). But improvements in cereal and staple crop yields remain incremental while 73% of the population rely on agriculture for income or subsistence (Ray *et al* 2012, Wineman *et al* 2020). In recognition of the challenges associated with growing population, food security and development, the Tanzanian government launched several initiatives designed to infuse the agricultural sector with private capital, including *Kilimo Kwanza* initiated in 2008, the Southern Agricultural Growth Corridor of Tanzania (SAGCOT) in 2010 (SAGCOT 2011) and Big Results Now in 2013 (URT 2016a). Since 2000, the government of Tanzania has received pledges of \$1 billion for agricultural investments coinciding with a flurry of 100 proposed or concluded LSLAs totaling ~350 000 ha (Bergius *et al* 2018, The Land Matrix 2021).

2.1.1. Site selection

Our analysis focuses on LSLAs that reached implementation where we can fully investigate spillovers to local communities. According to the Land Matrix, 42 LSLAs are in-operation in Tanzania. We obtained geo-location data for 25 LSLAs from existing databases, government reports and literature. From the set of 25 LSLAs, we selected four sites to be representative of key geographic, climatic and demographic variables (table S1, table S2 and figure S1). One bias in our sampled sites is towards greater proximity to rail systems, thus representing LSLAs with greater regional accessibility (figure S1). The four selected LSLAs correspond to a diverse set of important LSLA conditions: the presence of contract farming programs, subsistence versus commodity crops and agro-ecological characteristics (figures 2 and S2). Nevertheless, our selected LSLA sample does not feature land transactions among private owners, those smaller than 1000 ha, or forestry-based investments (figure S2).

The selected sites include the Kilombero Plantation Ltd (KPL), a rice plantation amidst a large valley of rice growers. As part of the land acquisition process, KPL displaced at least 230 households (Bergius 2015). The Hanang Wheat Complex (HAN) which cultivates wheat and barley in the relatively arid Manyara region and supplies local breweries. The Tanganyika Plantation Company (TPC) that relies on irrigation to grow sugarcane and is located near the town of Moshi with a high population density,

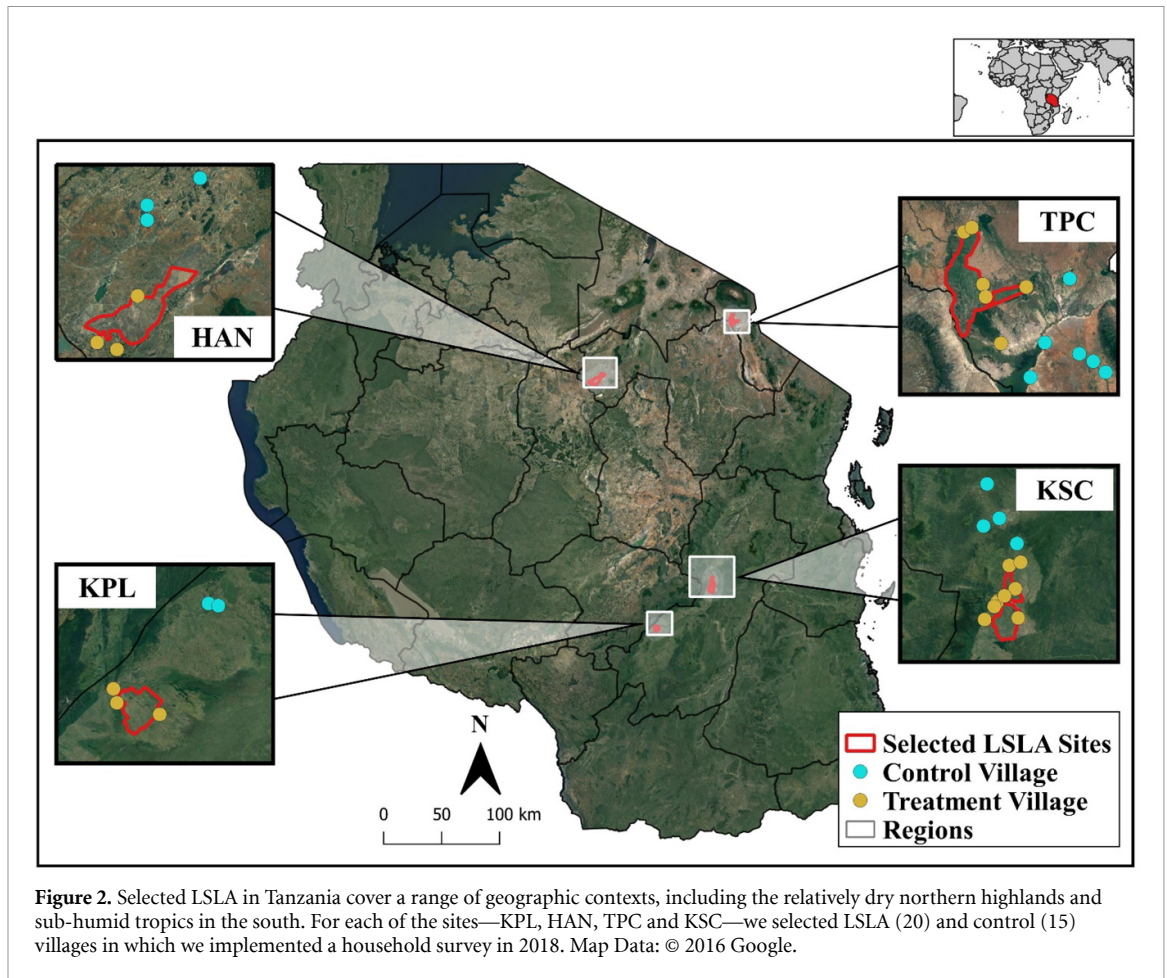


Figure 2. Selected LSLA in Tanzania cover a range of geographic contexts, including the relatively dry northern highlands and sub-humid tropics in the south. For each of the sites—KPL, HAN, TPC and KSC—we selected LSLA (20) and control (15) villages in which we implemented a household survey in 2018. Map Data: © 2016 Google.

improved infrastructure and more diverse employment opportunities. Finally, the [Kilombero Sugar Company \(KSC\)](#) which manages a large contract farming program to supply its sugarcane mills. KSC buys sugarcane from local farmers through a written contract negotiated with several ‘outgrower associations’ that, as of 2014, represented ~8500 farmers supplying 45% of KSC’s processed sugarcane (Sulle 2017). The sugarcane price is set within the contract but is a function of product quality (i.e. sucrose levels). Additionally, KSC withholds 10% of farmer proceeds that are adjusted to international market prices at end of season. Previous versions of the KSC contract farming program provided inputs for sugarcane establishment but are no longer available as outgrower associations increasingly coordinate planting, harvesting and transport (supplement section 1.1).

2.1.2. Quasi-experimental design and village selection

We use a quasi-experimental design, increasingly common in the study of environmental and social impacts of policy interventions (Ferraro and Hanauer 2014b). The main feature of our study design relies on identifying households directly affected by LSLAs (treatment) and households free of the influence of LSLAs (control) but with similar background characteristics. To achieve this, we define ‘treatment zones’ using a 5 km buffer surrounding each LSLA to identify

villages and confirm land tenure changes associated with LSLAs during fieldwork. To select plausible counterfactuals, we select non-LSLA villages by defining ‘control zones’ that exhibit similar socio-ecological characteristics to ‘treatment zones’ and apply eligibility criteria to control villages (supplement section 1.2). From the set of eligible villages within treatment and control zones, we randomly selected 35 villages where we implemented our household surveys in March–June 2018 (figure 2).

2.2. Household data

2.2.1. Household sampling and survey

We constructed a complete roster of 9022 eligible households across all selected villages from which we randomly selected 1003 respondents (526 treatment, 477 control). Eligible households resided in the selected villages prior to LSLAs and thus could provide retrospective responses on household conditions. For analysis, we removed households from our sample with missing data greater than 20% of the variable set. Missing data for the remaining households was gap-filled by generating multiple imputed datasets ($n = 10$) where replacement values are predicted using a mix of models for continuous, binary and ordered data (van Buuren and Groothuis-Oudshoorn 2011). With the focus of our analysis on agricultural productivity and its implications on food

security and income, we limit the household sample to 705 farmers (360 treatment, 345 control). More detail on the household sampling, survey design and data processing are available in supplement sections 1.3, 1.4 and 1.5, respectively.

2.2.2. LSLA mechanisms

We investigate the heterogeneous effects of LSLAs by first accounting for their unique conditions, and then assessing how different processes mediate their relationship to agricultural productivity at the household-level. Mediating processes that we investigate include land alienation, technology adoption of farming inputs, improved market access and contract farming (figure 1). It is important to note that contract farming entails improvements to market access and technology adoption. Thus, any estimates of market access and technology adoption channels should be considered as effects beyond those observed from contract farming. In all cases, the selected mechanisms are measured as binary variables after the occurrence of LSLAs to represent a chain of causal relationships between LSLAs, mechanisms and household agricultural productivity (supplement section 1.5.2).

2.2.3. Household outcomes

The outcome variables of interest include agricultural productivity, household income and food security. In the case of agricultural productivity, 75% of households in our survey cultivate multiple crops complicating comparison of crop yields. Therefore, we aggregate agricultural productivity similarly to other studies (see for example Omotilewa *et al* 2021) using two proxy measures: (a) the gross value of crop output per hectare and (b) the net value of crop output per hectare. The net value outcome is computed as gross values less inputs and hired labor costs. To ensure robustness of our estimates, we use two price modules to convert crop yields to market values. One from households reporting farm-gate prices and the second from the Agricultural Sample Census Survey in 2014/2015 (URT 2016b). It is important to note that our outcome variables for agricultural productivity do not include value from animal products, incorporate costs of family labor or account for subsistence versus market production. In our matching and conditioning approaches, however, we include covariates for household livestock and total on-farm labor (section 2.3).

Our measures of agricultural productivity comprise of several elements that may explain differences between LSLA and non-LSLA households. Therefore, we generate a second set of outcomes consisting of farm size, crop yield, selection of high-value crops (most commonly beans, cocoa and sesame), crop price, inputs and hired labor to provide deeper insight into agricultural changes surrounding LSLAs. Finally, we also consider livelihood outcomes of gross and net

agricultural incomes from the sale of crops as well as food-security measured as food sufficiency and expenditure (supplement section 1.5.3 and table S6).

2.3. Estimation methods

2.3.1. Covariate balance

Selection bias is commonly addressed using ‘matching’ methods that compare, for example, LSLA households with unaffected households that exhibit similar background characteristics, providing a statistical basis to estimate the effect of treatment (Stuart 2010). However, traditional matching methods require a large pool of control observations relative to treatment not available in our dataset (51% treatment, 49% control). Therefore, we use a weighting method known as entropy balance that reweights households to create a sample in which treatment is independent of confounders (Hainmueller 2012). We also report results based on covariate balancing propensity score and propensity score weighting to check the robustness of our results.

Several household- and location-specific characteristics influence agricultural productivity, farm incomes and food-security. Most notably, the suitability for agriculture, population pressure, household size and education influence our measures of rural well-being (Schultz 1964, Chayanov 1986, Turner and Ali 1996). A full set of geographic and household characteristics were prepared and used to balance baseline covariates between treatment and control groups (supplement section 1.5.4).

Our results indicate that balance improved across all covariates regardless of the weighting method used (figure S3). Entropy balance was particularly successful and reduced standardized differences of all covariates to <0.0001 (table S7). We therefore consider our reweighted estimator to successfully control for differences in observable covariates, but our estimation strategy does not account for unobserved confounders. Notably, where prior differences existed in outcomes across treatment and control households, results are potentially biased.

2.3.2. Average treatment effect (ATE)

We estimate the ATE of LSLAs on household agricultural productivity, incomes and food-security using ordinary least squares estimators. Model specifications include all covariates used in matching procedures (supplement section 1.6), covariate balance weights and a fixed effect for the four selected LSLA sites. We use cluster-robust standard errors at the village level ($n = 35$) to construct confidence intervals. To address uncertainty introduced from the missing data imputation procedure, we pool estimates across all imputations ($n = 10$) (Rubin 1988).

For outcomes of farm size, crop yields and crop selection—all components of agricultural productivity—we utilize the same estimation method of the ATE as described above. In the case of crop

price, however, we do not include household-level covariates, such as harvest quality or handling, thus crop prices are treated as exogenous. Rather, the estimation of LSLA effects on crop prices relies on site-level fixed effects and timing of the household survey to control for seasonal variation in prices.

2.3.3. Causal mediation analysis

To estimate the degree to which the effect of LSLAs on agricultural productivity passes through various mechanisms, we use nonparametric bootstrap estimators of the average causal mediation effect (ACME; Imai *et al* 2010, Tingley *et al* 2014). Standard errors and confidence intervals are determined by 5000 bootstrap replications. Final estimates, standard errors and confidence intervals are pooled across dataset imputations (Rubin 1988).

The ACME can be estimated under the ‘sequential ignorability assumption’ with nonparametric estimators (Imai *et al* 2010), which are less biased than linear structural equation models (Baron and Kenny 1986). We can test the plausibility of this assumption with a sensitivity parameter (ρ) representing the correlation between the residuals of the mediator and outcome regressions (Imai *et al* 2010). ρ reveals the degree to which an unobserved pre-treatment confounder would have to be correlated with the outcome and mediator to reverse conclusions (supplement section 1.6.2).

3. Results

3.1. Influence of LSLAs on household agricultural productivity

Separate from any productivity increases associated with transacted lands, we find that households proximate to LSLAs are associated with 20.2% (95% CI: 3.1%, 37.3%) higher agricultural productivity, measured as the gross value of output per hectare (table 1). Similarly, net agricultural productivity is 19.6% (95% CI: -0.6%, 39.8%) greater among LSLA households, suggesting that labor and input costs are similar across LSLA and non-LSLA villages.

Our results are robust to the use of different price datasets (table S8) and multiple weighting strategies (figure S4). Despite the consistency of results, it is plausible that LSLAs occur in locations of higher agricultural productivity. One indication of this relationship in our sample is that control households tend to be more remote and in less populated areas than treatment households (table S7). We test the hypothesis that LSLA occurrence is correlated with greater agricultural productivity by analyzing the normalized difference vegetation index (NDVI), a proxy for crop yields (Liu *et al* 2020), for baseline years. For three of four sites, NDVI values in control villages were equivalent or greater than treatment villages, indicating that our sample of LSLAs is not strongly correlated

Table 1. Quasi-experimental estimates of the average treatment effect (ATE) of LSLAs on household agricultural productivity. Log-transformed ATE estimates are converted to percentages using the equation: percent effect size = $(\exp(\beta_z) - 1) \times 100$. Full regression specifications and results are provided in table S8.

	Household agricultural productivity	
	Gross value of output (log(Tsh/ha))	Net value of output (log(Tsh/ha))
ATE- β_z (%)	20.2* (9.3)	19.6 ⁺ (7.5)
R ²	0.168	0.134
R ² (Adj.)	0.139	0.103
Num.Obs.	705	705
Num.Imp.	10	10

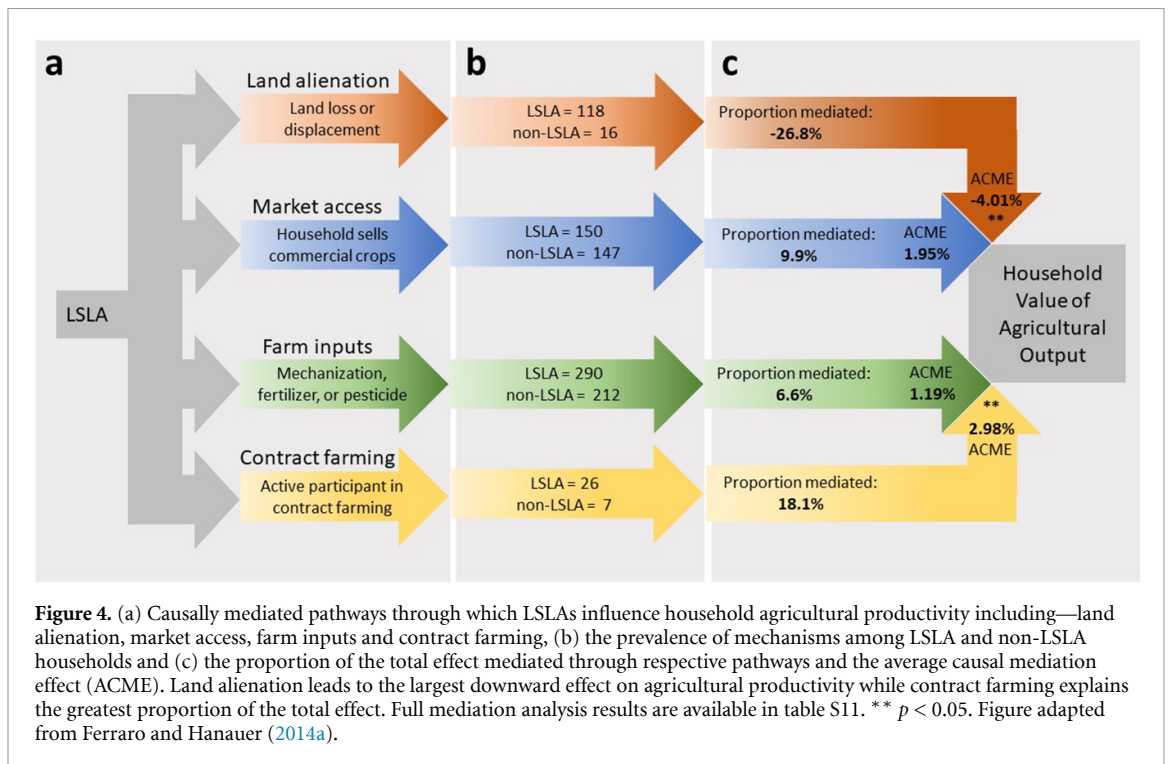
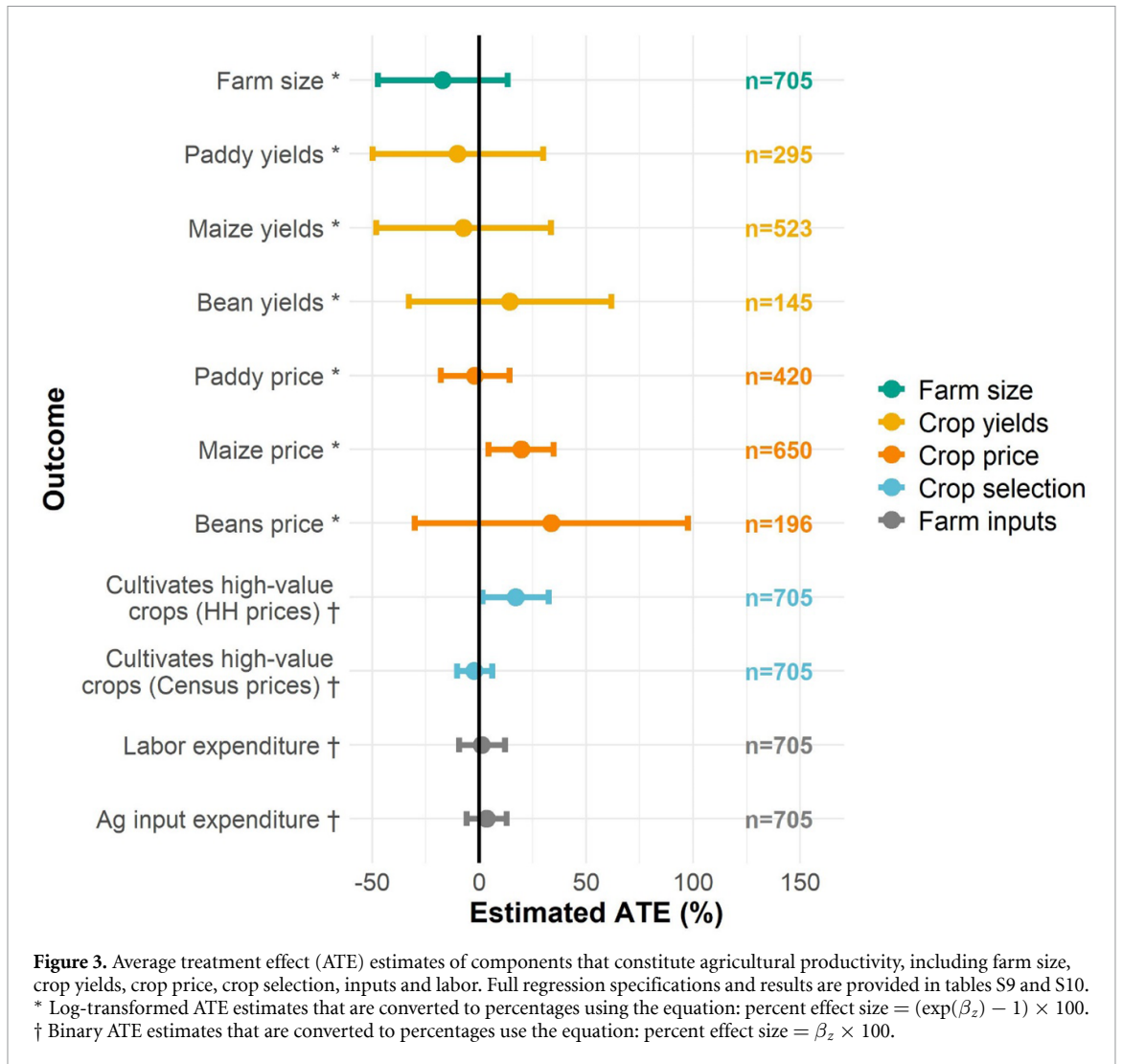
⁺ $p < 0.1$, * $p < 0.05$

with higher baseline levels of agricultural productivity (supplement section 1.7.1 and figure S5).

By further decomposing agricultural productivity into its various elements, we find that the observed effects are primarily driven by differences in crop prices and crop selection, as opposed to improvements in crop yields. Maize prices are notable with 19.6% (95% CI: 4.3%, 34.8%) higher farm gate prices among LSLA households (figure 3). In turn, households in the vicinity of LSLAs are 16.5% (95% CI: 1.5%, 32.5%) more likely to adopt high-value crops, though this result is sensitive to the choice of price data. It is important to note there is no evidence that crop yields among prevalent staple crops—maize, paddy and beans—improved among LSLA household. Similarly, LSLAs exert little influence on the likelihood of hiring labor or using additional farm inputs, explaining why gross and net agricultural productivity are consistent. Together, the results highlight changing market conditions, in the form of higher crop prices and farmer selection of high-value crops as the primary driver of increased agricultural productivity.

3.2. Quantifying LSLA mechanisms on agricultural productivity

Our causal mediation analysis reveals that higher agricultural productivity within LSLA households is principally driven by contract farming programs that account for 18.1% (95% CI: 0.56%, 47%) of the observed treatment effect, although only 4.7% of households participated in contract farming (figure 4). LSLAs, however, also have counteracting effects that dampen agricultural productivity. Land alienation was reported by 19% of households in our dataset that reduced the overall effect on agricultural productivity by 26.8% (95% CI: -71.3%, -4.0%). In other words, those exposed to land loss experience declines in agricultural productivity, highlighting how contrasting outcomes occur both across and within LSLA sites. The effect of land alienation is, in part, a reflection of displaced households residing on



lower quality land found in two of four LSLA sites per measures of slope and soil organic carbon (supplement section 1.7.2 and figure S6). Market access and farm inputs explain modest but insignificant proportions of the overall effect, thus we find no technology adoption or market access gains beyond those that arise through contract farming. Together, our results suggest heterogeneous responses of agricultural productivity to LSLAs based on access to contract farming or exposure to land loss.

In the case of contract farming, causal mediation results were robust to unobserved confounders not included in our analysis (supplementary section 1.7.3, figure S7 and table S12). Such an unobserved confounder would need to be positively correlated with the outcome and mediator and account for more than 36% of variation currently explained in the model. Pre-existing differences in agricultural productivity that plausibly drive enrollment into contract farming could be such a confounder explaining our result; however, we control for baseline precipitation and slope, therefore partially controlling for pre-intervention agricultural productivity. The land alienation mediation effect is less robust where our conclusions would be reversed for a confounder explaining up to 4.4% of the variation in the current model. Again, farm productivity may play a role where less productive farmers may be more willing to transfer land or have less negotiating power over land tenure (Suhardiman *et al* 2015).

3.3. LSLA impacts on household income and food security

We find that positive spillovers in the form of agricultural productivity do not materialize in improved farm incomes or food-security (table 2). Point estimates of agricultural incomes are negative but statistically insignificant. Null results may be an indication of unequal improvements where higher agricultural output is associated with larger farm sizes, suggesting consolidation of benefits among households with greater assets (figure S8). Alternatively, farmers who lost land are associated with a switch to higher value crops offsetting potential losses, though this pattern is not statistically significant (figure S8). Despite greater household agricultural productivity, estimates for food security outcomes point towards higher likelihood of food insufficiency and greater food expenditure, but estimates are insignificant.

4. Discussion

Our results suggest LSLAs in Tanzania improve agricultural productivity, a key linkage in accelerating agricultural transformation. Households proximate to LSLAs achieve 19.6%–20.2% greater agricultural productivity compared to their counterparts, primarily through higher crop prices or adoption

of higher-value crops. Our causal mediation analysis reveals agricultural value increases in the presence of contract farming projects, but that this benefit reaches only a small proportion of households (4.7%). In contrast, land alienation affects a much larger proportion of households (19%) who see declines in agricultural productivity. Paradoxically, despite the negative effects of land alienation, greater agricultural productivity is observed across our sample of households. One plausible explanation lies in the unequal distribution of benefits where households with larger farm sizes are more likely to access contract farming and adopt high-value crops (figure S8). Additional markers of agricultural transformation such as improved farm incomes and enhanced food security, however, are absent. Possible explanations include poor access to output markets, higher crop prices restricting food access, or elite capture of contract farming. In the context of LSLAs, our analysis shows that it is important to consider the mechanisms that account for outcomes for a deeper understanding of the connections between LSLA governance, agricultural growth and changes in well-being.

4.1. LSLAs and agricultural transformation

Our study holds important implications concerning the linkages at play between LSLAs and capital-led agricultural transformation. The infusion of large amounts of capital in agriculture is often hypothesized to modernize agricultural practices and market access that can spillover into local communities (Deininger and Byerlee 2011). We find little evidence that improvements in agricultural productivity are explained by adoption of modern farming tools such as mechanization, fertilizer, or chemical inputs, similar to previous studies in Mozambique and Ethiopia (Deininger and Xia 2016, Ali *et al* 2019). In our sample, the limited change in agricultural practices is reflected in the stagnant yields of important staple crops. Evidence of LSLA influence on crop yields is mixed. Rice yields declined near a sugar cane plantation in Sierra Leone (Bottazzi *et al* 2018) but in Ethiopia maize or wheat yields increased as a function of proximity to large farms growing the same crop (Ali *et al* 2019). Remote sensing analysis found little agricultural intensification—a proxy for yield increases—across a set of LSLAs in sub-Saharan Africa (Müller *et al* 2021). Altogether, the causal chain of improved farming practices, higher yields and greater agricultural productivity that LSLAs are often presumed to deliver are absent in our analysis and an uncommon finding across the literature.

Rather, our study highlights the role of changing market conditions, differing impacts across households and farmer adaptation to new conditions. Not only are crop prices elevated in proximity to LSLAs, but households act on those prices by adopting more high-value crops than non-LSLA households, leading to higher agricultural productivity. Households

Table 2. Quasi-experimental estimates of the average treatment effect (ATE) of LSLAs on household farm income and food-security. Log-transformed ATE estimates can be converted to percentages using the equation: percent effect size = $(\exp(\beta_z) - 1) \times 100$. Full regression specifications and results are provided in table S8.

	Ag. income		Food security	
	Gross Ag. income (log(Tsh))	Neg Ag. income (log(Tsh))	Food security (binary)	Food expenditure (log(Tsh/person))
ATE- β_z (%)	-5.1 (12.8)	-12.4 (41.4)	1.2 (3.7)	9.1 (10.2)
R2	0.516	0.282	0.169	0.261
R2 (Adj.)	0.499	0.256	0.1940	0.235
Num.Obs.	705	705	705	705
Num.Imp.	10	10	10	10

may adapt decision making on crop selection more quickly than they can adopt new agricultural practices for which other bottlenecks exist, such as lack of credit access, extension officers, or poor access to inputs (Jayne *et al* 2010). Not all households are affected equally, however, where a significant portion lose land to LSLAs resulting in lower agricultural productivity. Although smaller farms are consistently found to have higher agricultural productivity (see for example Omotilewa *et al* 2021), our results are partially explained by displaced household residing on lower quality land, a finding consistent with other studies (Zaehringer *et al* 2018). Altogether, our study finds agricultural change mediated by LSLAs is less related to technological spillover effects and instead by dynamic market conditions to which some households adapt.

4.2. LSLAs and livelihoods

Higher agricultural productivity is recognized as an important condition for poverty reduction (Barrett *et al* 2010) and why some argue LSLAs can generate greater well-being. While we find improved agricultural productivity surrounding LSLAs, no increases to farm incomes are found. This is partly explained by poor access to output markets surrounding LSLAs. Other studies find declining farm incomes due to higher labor costs, a result absent in our analysis but indicative of how LSLAs can put pressure on local markets that effect well-being (Hofman *et al* 2019). Finally, we find levels of food-security to be equivalent across LSLA and non-LSLA villages. Evidence elsewhere in literature is mixed. Worsening diets and declining food security were associated with export-oriented LSLAs across sub-Saharan Africa (Müller *et al* 2021) but there are also cases of greater incomes leading to improved food-security (Bottazzi *et al* 2018). Our findings on food-security are partially explained by the lack of improved farm incomes and yields. Alternatively, food access may be worsened by increased crop prices or contract farming programs that promote cash crops disconnected from local food production. Our analysis reveals ways in which improved agricultural productivity associated

with LSLAs is not necessarily a simple indicator of greater well-being and connections with prices, labor and markets must also be considered.

4.3. LSLAs and contract farming

Contract farming programs surrounding LSLAs were a primary explanation of increased household agricultural productivity in our analysis even with only 4% of households participating. Those who entered contracts did so primarily with the KSC representing 88% of households partaking in contract farming. Several explanations lie behind why the KSC contract farming program generates greater agricultural productivity for farmers. First, sugarcane yields and prices are higher than other crops. Although sugarcane is not considered a high-value crop in our analysis (table S6), the average sugarcane price reported by households is 1038 Tsh kg⁻¹ while the average price of all reported household crops is 798 Tsh kg⁻¹. At a national level in Tanzania, sugarcane growers achieve higher yields per area at 8.4 tons per hectare compared to other cereal crops such as maize (1.2 tons per hectare) or paddy (1.4 tons per hectare; URT 2016b). Finally, despite the positive impacts of LSLAs on agricultural productivity via contract farming, we observe negative but insignificant effects on farm incomes. One explanation lies within contract types. Where contracts specify crop price or quantity, as in the case of KSC, increases in off-farm incomes are more common than improvements to on-farm incomes—the outcome variable used in our analysis (Ruml *et al* 2022). Our findings on contract farming align well with other evidence that greater agricultural productivity is a result of high-value crop selection but with the added consideration that the crop in question—sugarcane—is also higher yielding.

While contract farming is an increasingly common phenomenon, there is evidence that some contract farming schemes generate benefits while others do not, making policy prescription difficult (Meemken and Bellemare 2020). Beyond the production characteristics of sugarcane, several features of the KSC contract farming program lend themselves to continued participation. Several features

KSC = a
sugar
company

of contract farming programs emerge across literature that explain participation and benefits including the role of farmer organizations and price volatility (Barrett *et al* 2012, Ruml *et al* 2022). Farmer organizations can increase participation and benefits to farmers due to lower transaction costs and better contract terms (Bachke 2019). In the case of the KSC, approximately 15 outgrower associations renegotiate contracts with KSC every three years on behalf of their members, although contract terms can favor larger farmers that typically manage the associations (Sulle 2017). Further, outgrower associations played a crucial role in establishing input markets for sugarcane cultivation, presumably lowering costs to KSC and explaining why contract terms evolved to no longer provide such inputs. Price volatility can be a major source of risk thus reducing participation and benefits (Barrett *et al* 2012). Farmers receive 90% of proceeds upon delivery with 10% held aside for differences in domestic and international prices, reducing their market exposure (Sulle 2017). The success of the contract farming program for farmers and the company in KSC is owed, in part, to farmers associations that help reduce transaction costs and price protections. As a result, our study reflects such elements of a contract farming program not necessarily present in all LSLAs that support similar programs.

4.4. Limitations and opportunities for future research

Our analysis provides one of the first assessments of the mechanisms that link LSLAs with agricultural productivity and indicators of agricultural transformation. Nevertheless, several limitations remain and highlight opportunities for future research. First, although we control for household baseline conditions in our estimation strategy, the outcomes of interest—agricultural productivity, incomes and food security—lack baseline measures. If pre-existing differences across treatment and control sites were present, then our results are potentially biased. Second, while our analysis at the household level adds understanding of the processes of agricultural transformation, landscape analyses, with remote sensing for example, can provide further insight into whether LSLAs lead to intensification on leased land and at larger geographic scales. Third, we limit our analysis to agricultural spillovers transmitted to farmers. Alternative spillovers include wage-employment (Herrmann 2017, Jung *et al* 2019) or migration (Kelley *et al* 2020) that can affect measures of well-being such as incomes and food-security (Rahman and Mishra 2020). Finally, that we examined four LSLA sites offers new, but limited insight into the heterogeneity of impacts. Greater variation exists among LSLAs both in Tanzania and globally. For example, our dataset does not include transactions between private parties, forestry- or vegetable-based LSLAs or LSLAs less than 1000 ha (figure S2) that

can be important to outcomes (Dell'Angelo *et al* 2017). Where possible, future studies should prioritize larger variation in LSLA characteristics alongside observational data that can account for changes over time.

5. Conclusions

Improving agricultural productivity is a major sustainability challenge with relevance to food-security and poverty. In the 21st century, many country governments with underperforming agricultural lands supported capital-investments in the form of LSLAs to boost agricultural production and improve rural livelihoods. Our study of four LSLAs in Tanzania analyzes these connections through a detailed mechanistic study and provides a cautionary tale. LSLAs are known to drastically alter agricultural landscapes (Davis *et al* 2020, Liao *et al* 2020b), yet in our study these costs created few benefits to rural households. In our sites of interest, LSLAs generated higher agricultural productivity that was primarily driven by market changes and failed to materialize in greater income or food-security. Further, household outcomes are contingent on LSLA implementation where land loss reduces agricultural productivity but access to contract farming is positive. Our analysis in Tanzania demonstrates that elucidating the mechanisms by which LSLAs relate to agricultural transformation can instruct efforts to reform LSLAs to meet the needs of rural communities.

Data availability statement

The data and code that support the findings of this study are openly available at the following URL: [10.5281/zenodo.6426194](https://doi.org/10.5281/zenodo.6426194).

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Ethical statements

Written informed consent was obtained from study participants. Research approval was obtained from the Institutional Review Board (IRB) and a research permit from the Tanzania Commission for Science and Technology (COSTECH; Permit No. 2018-443-NA-2018-134).

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