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The Fruits of Horticulture? Commercial Farming Across Local Economies in Senegal*

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Abstract

Can commercial farming stimulate economic development? Across sub-Saharan Africa, large commercial farms are increasingly promoted as engines of rural transformation. Yet whether they generate gains beyond the farm, and how these vary with local conditions, remains unclear. We construct a new spatial census tracing the expansion of large commercial farms in Senegal from 1999 to 2023 and combine it with satellite data, a farm survey, and population censuses. Local economic responses differ substantially across the four settings in which farms operate. In two horticultural regions with investments of similar scale and labor demand, census comparisons show increases in the share of women's employment in agriculture. Near major urban markets, where commercial farms replace smallholder production, farm expansion increases nighttime-light coverage and is associated with higher household wealth and in-migration. In the less densely populated river valley, where farms expand cultivated land, census estimates point to population growth, but we find no comparable nighttime-light response and weaker evidence of rising wealth. In the other two settings, we find little evidence of local economic change.

Keywords: Agri-business Development, Employment, Structural Transformation.
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1 Introduction

Can agriculture foster structural transformation in sub-Saharan Africa? A central development challenge in the region is moving workers from low-productivity smallholder agriculture into more productive employment (Lam and Elsayed 2021; Bandiera et al. 2022). Manufacturing has thus far absorbed only a small share of this reallocation (McMillan and Zeufack 2022; Gollin et al. 2026), which has renewed interest in whether productivity growth within agriculture can itself stimulate broader economic development.

One of the most contested questions in this debate is the role of large-scale commercial farming, which has gained prominence over the past two decades as a model for agricultural transformation (Byerlee et al. 2013). By 2020, concluded agricultural land deals by foreign investors in sub-Saharan Africa covered around 7.3 million hectares (Lay et al. 2021b). The expectation is that commercial farms raise agricultural productivity while stimulating surrounding local economies (Christiaensen and Martin 2018; Gollin 2023).

Yet whether these investments generate gains beyond the farm is far from clear *ex ante*. Commercial farms may create wage jobs, increase demand for local goods and services, and bring infrastructure (Haggblade, Hazell and Reardon 2010). But they may also displace smallholders and compete for land, water, and labor (Nolte and Ostermeier 2017; Baumgartner et al. 2015). Their effects are therefore likely to depend on what farms produce, how labor-intensive they are, and the economic environments in which they operate (Dercon and Gollin 2014; Gollin 2023). Despite sustained policy interest, evidence on the broader local-economy effects of large commercial farms remains limited, particularly on how these effects vary across production systems.

We address this gap by studying large-scale farming in Senegal. Since the early 2000s, the area under large-scale commercial farming there has roughly quadrupled, supported by government efforts to promote private agribusiness and irrigation (République du Sénégal 2014; Cisse et al. 2026). This expansion spans export horticulture, rice and sugarcane cultivation, and tree-crop plantations. This allows us to study both the broader local effects of commercial farming and how they differ across farm types and local economic settings within a common national policy environment.

We construct a new spatial census of large-scale commercial farms in Senegal.[1] We identify every farm above 200 hectares and digitize its production boundaries in every year from 1999 to 2023 using high-resolution satellite imagery. We validate our satellite-based mapping with a farm survey conducted in 2024. This further allows us to distinguish commercial farms

[1]The definition is not based on legal status but captures large-scale private-sector investments that may generate wage employment, rather than initiatives aimed at supporting smallholder farming.

from other spatial clusters of agricultural activity, including public irrigation schemes supporting small-scale producers, collective farming schemes operated by small-scale producers through farmer organizations, and abandoned projects that never entered production. The survey also collected information on crop-specific labor requirements. In total, we trace 45 large-scale commercial farms in Senegal, with the area under commercial production rising from approximately 12,000 hectares in 1999 to nearly 50,000 hectares in 2023.

The investments span four distinct geographic-production clusters: mixed commercial agriculture in the Senegal River Valley (SRV) in the north of the country, including horticulture, rice, sugar, and fodder production (26,200 ha), labor-intensive horticulture in Thiès (5,800 ha) close to the urban area of Dakar, extensive acacia plantations in the Ferlo (16,800 ha), and banana production in the southeast (800 ha).

We link our farm census to four satellite-based outcomes: annual cropland extent to measure agricultural expansion, dry-season vegetation greenness to proxy agricultural intensification, nighttime lights (NTL) to measure whether previously dark areas around the farms become lit, and built-up area to measure settlement growth. For these annual outcomes, we estimate event studies using the staggered difference-in-differences estimator of Callaway and Sant'Anna (2021), comparing farm footprints and surrounding areas up to 10 km away with untreated areas 15–40 km from farms within the same production cluster. This allows us to examine both pre-treatment trends and the evolution of effects following farm entry. We also exclude major urban and infrastructure confounders from the spatial analysis and assess robustness to alternative comparison-group distance bands and geographic exclusions.

We complement this analysis with three waves of Senegal's population and housing census (2002, 2013, and 2023) to examine changes in population, household wealth, and employment. Because the census data can only be compared over time at the commune level, a much coarser spatial unit than the satellite grid, the number of treated units is small. We therefore report randomization inference p-values for the census estimates. For population and household wealth, we use all three waves to examine both medium- and longer-run changes in communes exposed to farm expansion between 2002 and 2013. For employment, which cannot be reliably harmonized with the 2023 census, we instead use first differences between 2002 and 2013. Since we cannot assess pre-treatment trends with the census data, we interpret these estimates descriptively rather than causally.

Our analysis documents three features of the expansion of commercial farming in Senegal: where farms locate, the production shocks they create, and how surrounding areas adjust. Since our farms fall into four geographic-production clusters, we first show that farm placement across these clusters is strongly selective. Farms in the SRV are close to surface water,

while in Thiès they are concentrated in places that were already denser, better connected and wealthier. In the Ferlo and the southeast, farms enter substantially more remote areas. We present results separately by cluster to reflect these distinct economic settings.

Second, the four production clusters vary considerably in the scale and nature of the shock. Commercial horticulture reaches a remarkably similar scale in SRV and Thiès, covering about 5,800 hectares in each by 2023 and generating labor demand of the same broad order of magnitude. But the land-use changes are very different. In the SRV, the cropland share rises by around 15 percentage points after farm entry, consistent with irrigated cultivation expanding onto land previously used for grazing, fishing, and flood-recession agriculture. In Thiès, by contrast, cropland does not increase, while dry-season vegetation becomes greener: commercial farms take over and intensify land that smallholders were already cultivating. The acacia plantations in the Ferlo, which expand onto land used mainly for seasonal pastoralism, have a much larger land footprint but substantially lower and more seasonal labor demand per hectare. Finally, the banana production in the southeast covers less than 800 hectares and enters areas characterized by forest, long fallows, and shifting cultivation. Taken together with the placement patterns above, the SRV-Thiès comparison is especially informative: investment is similar in scale and labor demand, but the pre-existing land use and surrounding economic setting differ markedly.

Third, the adjustments outside the farm also differ across clusters. Two patterns are common to the horticultural regions. Census estimates point to similarly sized increases in women's crop-agriculture employment shares in both the SRV and Thiès, consistent with horticulture's high female labor intensity, although only the SRV estimate is statistically significant at the 10 percent level. Pre-existing settlements also expand only modestly in both regions. Beyond these commonalities, however, the evidence begins to diverge.

In Thiès, the share of surrounding area that is lit increases by around ten percentage points after farm entry and reaches around 12 percentage points six to eight years later. This result is robust to alternative treatment radii and geographic exclusions, and remains similar when we restrict the analysis to the period before the new airport opened. Household wealth also rises, with positive estimates for flush toilets, television ownership, and car ownership in 2013. The wealth-index estimate remains positive through 2023. The share of employed women working in services also rises by 3.5 percentage points, with positive estimates for education and health, as well as hairdressing and beauty services. We find little evidence of changes in overall employment rates. Working-age population estimates are positive but imprecise, while cross-regional in-migration rises substantially by 2023.

The SRV follows a different pattern. Census estimates point to working-age population

growth by 2023, alongside a positive but imprecise in-migration estimate. However, we see no comparable nighttime-light response within 10 km of the farms. Evidence of higher household wealth is less persistent, while estimates of non-farm employment changes remain mostly imprecise. We also do not detect a nighttime-light response in the Ferlo, where labor demand per hectare is much lower, or in the southeast, where commercial farming covers a much smaller area. The contrast is therefore strongest between the SRV and Thiès: despite similarly scaled, labor-intensive horticultural investment, the evidence of broader economic change is stronger in Thiès, particularly for nighttime lighting and persistent household wealth gains.[2]

One interpretation of these differences is that similar farm-level shocks propagate differently depending on the surrounding economic environment. Thiès is much denser, closer to Dakar, and better connected to major markets than the SRV. These features may make worker and firm spending more likely to translate into nearby services and complementary investment, and may also lower the cost of extending infrastructure such as electricity. In the sparser SRV, substantial demand for agricultural labor may therefore coexist with less detectable change in surrounding activity. Given the limited power for formal cross-cluster comparisons, we view this interpretation as suggestive, but it offers one coherent account of why similarly scaled horticultural investments are associated with different local trajectories.

Our paper makes three main contributions to the literature. First, we construct an annual spatial record of realized commercial-farm expansion, to our knowledge the first for any country in sub-Saharan Africa. Existing data fall short in two ways. Land-investment databases record announced or contracted rather than cultivated areas (Anti 2021; Raimondi and Scoppola 2018; Lay et al. 2021b), and many projects are never implemented, or only partially and years later (Lay et al. 2021b). Satellite-based land-cover products, in turn, show where cropland expands but cannot distinguish commercial estates from smallholder fields or public irrigation schemes. These sources can therefore mismeasure the location, timing, and scale of commercial-farm expansion. By combining annual satellite imagery with field verification and our farm survey, we trace the actual production footprint and crop type of every large commercial farm in Senegal from 1999 to 2023, allowing us to link changes in surrounding local economies to realized farm entry and expansion.

Second, we examine how the local economic consequences of commercial farming vary across production systems and economic settings within one country. In doing so, we con-

[2]When we formally test whether the census estimates differ between the two regions, the household wealth difference is statistically significant at the 5% level in 2013 and at the 10% level in 2023. For population, in-migration, and employment, the small number of treated communes does not allow us to distinguish the two regions, and we cannot separately identify the channels underlying the contrast.

tribute to the debate on the role of large farms in agricultural transformation (Collier and Dercon 2014; Dercon and Gollin 2014; Deininger and Byerlee 2012; Jayne et al. 2022; Gollin 2023) and the related literature on their employment effects (Nolte and Ostermeier 2017; Anti 2021; Glover and Jones 2019; Mercandalli et al. 2021; Aremu, Fabry and Meemken 2024). Existing evidence documents both benefits and trade-offs: large-scale land acquisitions can shift workers into agricultural wage employment while reducing household spending (Anti 2021), and gains for neighboring smallholders vary across commercial-farming models (Glover and Jones 2019). In Senegal, previous studies of export horticulture show that large-farm employment raises household incomes and is particularly important for women, but have largely focused on household- and worker-level outcomes (Maertens and Swinnen 2009; Maertens and Verhofstadt 2013; Van den Broeck and Maertens 2017; Fabry, Van den Broeck and Maertens 2022).

Much of the empirical evidence to date focuses on particular crops or dimensions of adjustment, including oil palm in Liberia (Sonno and Zufacchi 2025), cut flowers in Kenya (Bishop, Moneke and Zipfel 2026), and the effects of large-scale land acquisitions on agricultural production and deforestation in Ethiopia (Kassie et al. 2026). The Kenyan flower-farm study also documents broader local responses, including urbanization and improvements in living standards. Yet whether similar responses arise across different commercial-farming settings remains unclear. We show that even horticultural investments of similar scale and labor demand can be associated with different patterns of adjustment in surrounding local economies.

Third, our findings speak to a broader literature on how economic geography shapes the propagation of local production shocks. A growing literature emphasizes that agricultural productivity and the gains from agricultural interventions depend on market access and economic geography (Gáfaro and Pellegrina 2022; Bergquist et al. 2026). We add complementary reduced-form evidence from realized private investment, using within-country contrasts in how similar agricultural investments play out across very different local environments.

2 Setting and Potential Channels

2.1 The Expansion of Commercial Farming in Senegal

Senegal's agricultural sector plays a central role in the country's rural economy with roughly two-thirds of the rural population depending directly on it for their livelihoods (FAO 2021). For decades, the sector has been characterized by low productivity, small farms, limited mechanization, and high exposure to rainfall variability. A major policy shift came in the

early 2000s, formalized in the 2004 *Loi d'orientation agro-sylvo-pastorale*, which established a framework for agricultural modernization and private investment (République du Sénégal 2004). Large-scale commercial agriculture subsequently became more prominent in Senegal's agricultural development strategy. Successive governments, with support from international donors, further promoted these investments by allocating land, developing irrigation infrastructure, and partnering with export-oriented agribusinesses (Cisse et al. 2026; République du Sénégal 2014).

These domestic policy changes coincided with a broader rise in investor interest in African agriculture. Following the 2007–2008 global food price spike, investment in African farmland increased sharply, contributing to a surge in large-scale land acquisitions (Lay, Nolte and Sipangule 2021a). With its fertile soils, irrigation potential, and good port access, Senegal emerged as an attractive destination for agricultural investment (Bourgoin et al. 2023).

Commercial farming consequently expanded sharply. Based on our own data, the area under commercial cultivation roughly quadrupled, from about 12,000 hectares in 1999 to nearly 50,000 hectares in 2023, with the largest increases after 2012 (Figure 1). Much of this expansion was in horticulture and coincided with a major increase in Senegal's fresh fruit and vegetable exports. Figure 2 compares the area of horticultural commercial farms in the SRV and Thiès with export volumes. The two series rise together, particularly after 2009. By 2021, export volumes had more than quadrupled since 2010, while the area under commercial horticulture had more than tripled. The expansion of large-scale commercial farms was therefore an important part of the broader transformation of Senegal's horticultural sector over this period.

2.2 Production Systems and Geography

The aggregate expansion of commercial agriculture in Senegal conceals large differences in what farms produce, how they produce it, the land they occupy, and the local economies in which they operate.

Based on crop types and geography, we identify four distinct clusters of privately owned large-scale commercial farms in Senegal (Figure 3), each with its own pre-existing land-use system. Table 1 compares the pre-entry characteristics of communes receiving commercial farms with those of communes elsewhere in Senegal, showing that the correlates of farm placement differ markedly across clusters. In both the SRV and Thiès, farms locate in or near communes that were wealthier and more electrified than the comparison communes at baseline, but other correlates differ: proximity to surface water in the SRV, versus higher population density and proximity to Dakar and major roads in Thiès. In the Ferlo, farms

enter communes with less crop-agriculture employment but similar living standards, while in the southeast they enter more remote and greener areas. These distinct placement patterns reflect, in part, different production requirements: river access for irrigation in the SRV; coastal climate, shallow groundwater and market access in Thiès; semi-arid, sandy soils for acacia in the Ferlo; and greater precipitation and river access for banana production in the southeast. The clusters therefore represent distinct agro-ecological and economic environments, motivating our decision to analyze them separately.

The clusters also differ sharply in the scale and economic intensity of commercial-farm expansion. Appendix Table A.1.1 reports crop-specific labor requirements from our 2024 farm survey. Horticultural crops have particularly high labor demands, reaching approximately 2,700 eight-hour person-days per hectare annually for green onions. By 2023, commercial horticulture covered about 5,750 hectares in the SRV and 5,800 hectares in Thiès. Combining these areas with crop-specific labor requirements yields estimated annual labor demand of roughly 1.7–4.3 million eight-hour person-days in horticulture in the SRV and 1.2–3.7 million in Thiès. The horticultural investments in the two regions are therefore of a similar order of magnitude in both land area and labor demand. The other clusters look quite different. Plantations in the Ferlo cover about 16,800 hectares, a much larger land footprint, but acacia production requires only around 144 person-days per hectare per year and generates almost no permanent employment in our survey. The area under cultivation in the southeast is much smaller, covering less than 800 hectares by 2023, with banana production requiring around 525 person-days per hectare per year. Land area alone is therefore a poor measure of the size of the economic shock created by commercial farming. Labor demand is also highly seasonal: for crops other than banana and acacia, mean female employment per hectare at peak is approximately 26 times permanent female employment (Appendix Table A.1.2).[3]

The SRV and the northern alluvial plains were among the first regions where large-scale commercial farms emerged, as extensive rice and sugarcane schemes expanded into territories historically used for flood-recession agriculture ("cultures de décrue") and seasonal pastoralism. Today, the cluster is the most heterogeneous of the four. It combines export horticulture with sugar, rice, fodder and mechanized potato and onion production. While horticulture generates substantial labor demand, the more mechanized systems require less labor, concentrated in particular phases of cultivation.

In Thiès, commercial-farm entry in our data begins in 2002. Commercial farms in Thiès are almost exclusively labor-intensive horticultural operations. Investors have largely fo-

[3]Peak-season and permanent employment figures are reported at the farm rather than crop level. Crop-level working hours suggest higher labor requirements in horticulture than in staple crops within the "all other crops" category. Banana farms maintain a larger permanent workforce per hectare, predominantly composed of men.

cused on horticultural crops including tomatoes, onions, melons, cucumbers, and tree crops such as mango and papaya, supplying export markets and urban consumers around Dakar. Production relies heavily on manual labor for planting and weeding, with women supplying a large share of the workforce, particularly in harvesting, sorting and packing. Commercial farms in Thiès are also not green-field investments. Instead, they were established on land characterized by diverse smallholder farming systems. The local economy of Thiès is also considerably denser (Figure A.8.1) and better connected to markets than that of the other clusters due to its proximity to Dakar.

In the sylvopastoral zone of Ferlo (Louga region), commercial acacia plantations producing gum arabic begin to appear in 2005, with additional plantations entering thereafter, on land previously used mainly for seasonal pastoralism.

Finally, in the southeast of the country, commercial banana plantations begin to appear in 2011. These were established on forest land and land with long-fallow systems and shifting cultivation. Unlike in the other clusters, commercial farms here did not introduce a new production system. Bananas have long been grown in the region by smallholders and the plantations therefore primarily expand an existing production system. The domestic market for the local small-fruited variety is limited, as consumers prefer larger varieties imported from neighboring countries. With only three farms, this is by far the smallest investment cluster. It is also located in a remote, sparsely populated part of the country. Thus, despite moderate labor intensity per hectare, the aggregate local shock is considerably smaller than in the other clusters.

2.3 Channels of Local Economic Change

The differences described above motivate several channels through which commercial farms may affect surrounding areas. Large investments may generate limited local spillovers if they create little employment or few linkages to the surrounding economy. Even where labor demand is similar, spillovers may depend on population density and market access. Similar responses in the SRV and Thiès would be consistent with labor-intensive horticulture itself generating local spillovers; stronger responses in one region would instead point to an important role for the surrounding economic environment.

Direct employment. The employment effects of commercial-farm expansion may depend both on labor intensity and on what farms replace. In Thiès, where commercial farms expand primarily onto land already cultivated by smallholders, farm entry may reallocate workers from own-farm production into hired labor on commercial farms. Previous research on Senegal's export horticulture sector documents a shift from smallholder contract farm-

ing to integrated estate production, alongside the expansion of wage employment (Maertens and Swinnen 2009; Fabry, Van den Broeck and Maertens 2022). Total agricultural employment need not rise, however, even if agricultural wage employment does. In the SRV, by contrast, farms expand in areas previously used for flood-recession agriculture, grazing and fishing. This may increase total agricultural employment, potentially at the expense of these pre-existing activities.

Gender differences. The direct-employment channel also has an important gender dimension. In Senegal's horticultural export sector, women hold about two-thirds of jobs (Fabry, Van den Broeck and Maertens 2022), and our own labor-intensity data similarly show particularly high female labor demand in horticulture (Appendix Table A.1.1). The high female labor intensity of horticulture means that any direct employment response may therefore be particularly visible among women.

Product-market and infrastructure linkages. Commercial-farm expansion may also generate indirect employment through transport, trading, processing and other activities involved in moving the agricultural produce from the farm gate to consumers. These linkages may be particularly important for market-oriented horticulture, where perishable goods require rapid transport, sorting, packing, refrigeration and cold storage. Electricity-planning documents for Thiès explicitly link network expansion to the productive needs of horticultural areas (Engineering & Environment Services 2019; Energy Sector Management Assistance Program 2007).

Commercial horticulture in Senegal supplies both export and domestic markets (Maertens and Swinnen 2009; Fall et al. 2000; Ndiaye 2021). Evidence from the Saint-Louis–Mpal area documents established trading networks involving intermediaries (PACE Sénégal 2024), while market surveys show substantial flows of horticultural produce from the SRV to Dakar and the city of Thiès (Van den Broeck, Van Hoyweghen and Maertens 2018). As commercial horticulture expands, these networks could support additional employment in transport and trade, although some of this activity may occur outside the areas captured by our treatment measures.

Local demand. If farms raise local incomes, workers' and firms' spending may stimulate locally supplied services and small-scale manufacturing, alongside improvements in living standards and broader economic activity. Maertens and Swinnen (2009) show evidence of rising incomes around commercial horticulture farms. Related evidence from African mining shows that large local production shocks can generate growth in service-sector employment, particularly for women (Kotsadam and Tolonen 2016). The strength of these local multipliers may depend on the density and connectivity of the economy receiving the shock. They may

therefore differ between the dense, well-connected Thiès and the much sparser SRV, even where horticultural investment and direct labor demand are similar.

Changes in labor demand and local incomes may also affect where people live. In a dense and well-connected region such as Thiès, new jobs and rising incomes may attract people from other parts of the country. Fabry, Van den Broeck and Maertens (2022) document that workers on horticultural farms include migrants from other regions. In a sparser region such as the SRV, where alternative jobs are scarce, new employment may instead mainly reduce out-migration of the local population.

3 Data

Our analysis combines four data sources: (i) a spatial dataset tracking annual commercial-farm expansion from 1999 to 2023, validated by a 2024 farm survey that also records crop-specific labor requirements by gender; (ii) satellite land-cover and vegetation data (2000–2022), aggregated to a nationwide 500 m grid to measure agricultural expansion, intensification, and settlement growth; (iii) nighttime lights (NTL) from Chiovelli et al. (2026), measured on a 1 km grid (2000–2023); and (iv) random 10 percent samples of Senegal's 2002, 2013, and 2023 population and housing censuses, harmonized at the commune level. This section describes each of these data sources in turn.

3.1 Commercial Farm Data

Commercial farm expansion (1999–2023). We construct a spatial census of commercial farms exceeding 200 hectares in Senegal between 1999 and 2023 using annual high-resolution satellite imagery. The 200 ha threshold is widely used to define large-scale farming and aligns with the Land Matrix database (Kassie et al. 2026; Lay et al. 2021b; Nolte and Ostermeier 2017). Starting in 1999 aligns with the availability of household data and captures the expansion of large-scale commercial farming that accelerated after 2000 (Lay et al. 2021b).

We identify farms and farm clusters using records from the Land Matrix Initiative and visual inspection of satellite imagery across Senegal. We validate the mapping against official sources, including regional maps produced by SAED (*Société nationale d'Aménagement et d'Exploitation des Terres du Delta du Fleuve Sénégal et des Vallées du Fleuve Sénégal et de la Falémé*), and through extensive field verification. For each site, we digitize annual production boundaries using Google Earth Pro. These polygons capture gradual expansion or contraction of cultivated area and allow us to identify farm entry and treatment timing within our spatial units.

Commercial farms often comprise multiple non-contiguous plots. We therefore group plots into a single farm when they belong to the same owner and are located within five kilometers of each other. The resulting dataset covers 45 commercial farms comprising 65 spatially distinct production sites.

Our 2024 farm survey also helped validate our farm mapping. We visited 32 mapped farms for which information on cultivated area or business models was ambiguous. These visits verified cultivated area, implementation status, and private-sector operation, allowing us to distinguish commercial farms from government irrigation schemes serving small-scale producers and abandoned projects subsequently cultivated by smallholders, which can look similar in satellite imagery. Beyond labor requirements and workforce composition by gender, the survey collected information on crop composition, irrigation methods, mechanization, and cultivation practices.

3.2 Secondary Satellite Datasets

Annual cropland (2000–2022). To measure agricultural expansion, we use the African annual cropland distribution (AFCD) dataset developed by Lou et al. (2025), which provides annual binary crop/non-crop maps at 30 m spatial resolution for the years 2000–2022. The dataset uses Landsat imagery, random forest classification, and continuous change detection. Cropland is defined as land used for annual and perennial herbaceous crops for food, fodder, and biofuels, under both rainfed and irrigated production; perennial woody crops and permanent pastures are excluded. The maps therefore measure changes in the extensive margin of annual and herbaceous crop cultivation. The dataset closely matches national cropland area estimates reported by the Food and Agriculture Organization (FAO). It also performs well in fragmented agricultural landscapes, with Lou et al. (2025) documenting its ability to identify dispersed traditional rainfed cultivation in Senegal.

Dry-season vegetation greenness (2000–2022). Because the AFCD does not distinguish rainfed smallholder agriculture from more intensive irrigated production, we proxy agricultural intensification using dry-season greenness, measured by the Normalized Difference Vegetation Index (NDVI) from the Terra Moderate Resolution Imaging Spectroradiometer (MODIS) Vegetation Indices (MOD13Q1) Version 6.1 (Didan 2021).[4] We use 2000–2022 to match the land-cover data. Dry-season NDVI is the mean of the seven composites whose start dates fall between days 33 and 129 (2 February to 24 May). Because most rainfed an-

[4]We use observations from the Terra satellite only, so that the number of observations per season does not change after a second complementary satellite was launched in mid-2002.

nual vegetation in Senegal has senesced by these months, dry-season greenness is particularly sensitive to irrigated and other year-round vegetation.

Nighttime lights (2000–2023). As a proxy for economic development, we use the harmonized NTL series of Chiovelli et al. (2026), combining DMSP (2000–2012) and VIIRS (2012–2023) observations into a consistent series for 2000–2023. It corrects for top-coding, blooming, and sensor differences, particularly important in low-income settings where dim lights can be obscured by blooming from brighter neighboring pixels. We use the series on its native grid of 30 arc-second cells, roughly 1 km across, with pixel values ranging from 0 to 63. Our main outcome is the share of cells with a positive NTL value, capturing whether previously dark areas become lit. We prefer this extensive-margin measure because much of rural Senegal is initially unlit, while average intensity can be driven by a few relatively bright urban cells. Because the NTL cells are larger than the land-cover cells, we exclude 500 m cells whose corresponding 1 km NTL pixel overlaps a farm polygon, so that the surrounding-area estimates do not capture light emitted by the farms themselves. We similarly exclude mine and quarry footprints, since light emitted by these sites may reflect on-site operations rather than broader economic activity in surrounding areas.[5]

Built-up area (2000–2022). To measure settlement growth, we use the GLC_FCS30 global land cover product (Version 2) by Zhang et al. (2024). GLC_FCS30D provides annual maps at 30 m resolution with 35 land-cover subcategories, covering 1985–2022; we use 2000–2022. The product is derived from the full Landsat archive using a continuous change-detection approach in which land-cover change is identified from breaks in each pixel's spectral time series, and the classification is updated only in years in which a change is detected. This makes the annual maps considerably more stable than products classified independently year by year.

The built-up share corresponds to impervious surfaces (class 190). GLC_FCS30D sometimes classifies paved roads as built-up. To correct for this, we subtract from each cell's built-up share its road length multiplied by the estimated built-up share per meter of road, calculated separately for each year using rural cells crossed by motorways, trunk roads and primary roads in OpenStreetMap. We use the road-corrected share throughout. We define a settlement present in 2000 as an 8-connected cluster of cells with a road-corrected built-up share of at least 0.05 in 2000, and measure its growth over the settlement and every

[5]To validate the NTL results, we also use administrative data from the Senegalese Ministry of Energy that list villages in Senegal with their geographic coordinates, electrification status and year of grid connection if available. We use these connection dates to examine grid connections of villages near commercial farms in Thiès (Appendix Figure A.3.3).

cell within 1 km of it. We remove from the zones all cells within 350 m of a commercial farm, so that the farms' own buildings are not counted as settlement growth, as well as one non-farm installation (the Keur Momar Sarr water treatment plant) in the SRV. For each settlement-year, the outcome is the road-corrected built-up area divided by the zone's total area.

3.3 Household and Individual-Level Data

Senegal Census (2002, 2013, 2023). We use random 10 percent samples of the microdata from the 2002, 2013, and 2023 population and housing censuses. For each wave, we merge household- and individual-level files using the original census identifiers, combining household characteristics with individual demographic, migration, and labor market information. We work directly with the original census microdata rather than relying on the IPUMS harmonized extracts, as these do not provide commune-level geographic identifiers, which are central for our empirical analysis.

Because questionnaires and coding schemes vary across census waves, we harmonize geographic variables (including commune names), household characteristics, individual demographics (age, sex, marital status, and education), migration status, and employment status to preserve comparability over time. Appendix A.7 provides details.

The analysis of the census outcomes is conducted at the level of the commune, the fourth administrative level in Senegal (below region, department and arrondissement) and the smallest unit that can be observed consistently across all three censuses. Senegal's communes were split and redrawn several times during the study period, so we build a harmonized set of units on the 2002 boundaries: we reconcile commune names across waves, track administrative splits, and assign all census observations to the resulting 277 communes, excluding urban Dakar.

The census does not report income or consumption, so we proxy living conditions with a wealth index based on housing characteristics, amenities, and household assets. We harmonize eighteen indicators across the three censuses: ownership of a television, refrigerator, telephone, computer, air conditioning, radio, car, motorbike, and bicycle; grid electricity; and three-level categorical measures of the water source, floor material, toilet type and number of rooms, each entered as two indicators. The index is the first principal component of these indicators. We estimate the loadings once, pooling the three censuses with equal weight per wave, and apply them unchanged to all households. This ensures consistent weighting over time without anchoring the index to the asset structure of a single year. We estimate the loadings using only households in never-treated communes, so that responses to farm entry

do not influence the weights. Finally, we standardize the index to mean zero and unit standard deviation across all households in 2002 and aggregate it to commune means, weighting households equally.

We compute working-age (25–54) population by commune and sex, and the number of in-migrants, defined as persons born in a different region of Senegal from the one in which they are enumerated. We construct birthplace using the harmonized migration variable in 2002 and by comparing birthplace codes with the region of enumeration in 2013 and 2023. Our in-migrant measure therefore captures moves across Senegalese regional boundaries; persons born abroad are not included in this count. For the population analysis, both outcomes pool men and women and enter in logarithms.

We measure labor market outcomes for individuals aged 25–54, separately by sex, using the employment rate and the distribution of employment across seven broad sectors based primarily on occupation. The census records respondents' main activity over the preceding 12 months. The employment rate is defined as the number of employed persons divided by the population of the same sex and age group. We then classify the employed into the following seven occupational categories and compute each category's share of employment: (i) crop agriculture; (ii) other primary activities including livestock, fishing, forestry and mining; (iii) manufacturing (incl. food manufacturing); (iv) construction; (v) transport; (vi) trade, and (vii) other services. Workers whose sector cannot be identified are excluded from this denominator.

We restrict the employment analysis to the 2002 and 2013 census waves. Although the 2023 census also records occupation using ISCO-08, many codes do not appear to represent credible occupational classifications, and the auxiliary fields needed to recover these observations are insufficiently comparable with 2013. We therefore cannot reliably harmonize employment sectors through 2023.[6]

4 Methodology

We estimate the effects of large-scale commercial farms by exploiting their staggered entry across Senegal between 2000 and 2023, recorded in our annual farm dataset. Our difference-in-differences design compares changes in outcomes in locations exposed to farm entry with those in untreated locations. Identification relies on parallel trends in the absence of farm entry. Section 4.4 details the sample restrictions and diagnostic and robustness checks used

[6] After classification, the shares of employed men whose sector remains unclassified are 1.4, 1.2, and 9.5 percent in 2002, 2013, and 2023, respectively; the corresponding shares for women are 12.2, 12.9, and 24.1 percent. Appendix A.7 details the labor-market harmonization.

to assess this assumption.

We distinguish between annual spatial outcomes, observed at the grid-cell or settlement level, and census outcomes, observed at the commune level. The former allow event-study analyses with longer pre- and post-treatment windows; the latter provide fewer periods and treated units. For land use and nightlight luminosity, we estimate effects separately for each of the four production clusters (SRV, Thiès, Ferlo, and southeast). The settlement and census analyses focus on the SRV and Thiès. The clusters differ in agro-climatic conditions, crop mix, labor intensity and the land use the farms replace (see Section 2), so a pooled estimate could average treatment effects that could go in different directions.

4.1 Estimator

As treatment is staggered and effects are likely to differ over time, conventional two-way fixed effects estimators can produce estimates that do not need to correspond to any well-defined average effects (de Chaisemartin and D'Haultfœuille 2020; Goodman-Bacon 2021; Sun and Abraham 2021; Roth et al. 2023). We therefore use the estimator of Callaway and Sant'Anna (2021), which estimates group-time average treatment effects using comparisons with untreated units and allows these effects to vary across treatment cohorts and over time. We use never-treated units as the comparison group. For the event-study estimates, we use a universal base period, normalizing the year immediately before treatment to zero for every cohort. This puts both pre- and post-treatment coefficients on a common reference period.[7]

All p-values reported in the paper, including the pre-trend tests, are from randomization inference; the confidence bars in the event-study figures and the standard errors in the tables are shown as a guide to precision only.

4.2 Spatial Event Studies

We use spatial units below the administrative level because the effects of commercial farms may be highly localized. Across the spatial event studies, we compare treated units with never-treated units located 15–40 km from the nearest farm, restricting comparisons to units whose nearest farm belongs to the same production cluster. The land-cover and vegetation outcomes are aggregated to a 500 m grid. For the farm-footprint analysis, a cell's entry year G_i is the first year in which a farm operates within 350 m of the cell. We define each farm's footprint as its maximum extent over 2000–2022, i.e. the union of its annual polygons, and

[7] By contrast, the default varying-base implementation constructs pre-treatment coefficients from changes between consecutive periods while post-treatment coefficients are measured relative to $e = -1$, an asymmetry that can complicate the interpretation of event-study plots (Roth 2026).

classify grid cells within 350m of that extent as footprint cells.

We also examine outcomes in the area surrounding the farms. For land use, we estimate effects in four disjoint distance bands of 0–4 km, 4–6 km, 6–8 km, and 8–10 km from the farm footprint, always excluding the footprint itself. For the surrounding-area specifications, entry is defined by the first year in which a farm comes within the relevant distance band. Treatment is absorbing, and cells already treated at the start of the panel are removed. Event years run from 2002 to 2022, and we report coefficients for up to eight years before and after entry.

For NTL, our main specification pools cells between the farm footprint and 10 km, and we additionally estimate effects across narrower distance bands. Because all distances are measured from the farm's maximum extent, a cell's distance band does not change over time. Cells close to several farms are assigned to the farm to which they are closest. The NTL analysis uses 500 m cells assigned the lit status of the corresponding 1 km night-light cell; cells whose night-light pixel overlaps a farm are excluded. For the surrounding-area NTL and settlement specifications, we additionally drop treated units that were already within 15 km of a farm in the year before entry, so that treated units are "fully" unexposed in the pre-treatment period.

Finally, we estimate settlement-level event studies for the SRV and Thiès. We identify settlements already present in 2000 and follow the built-up share of the settlement and its surrounding 1 km zone. A settlement is treated when a commercial farm first comes within 10 km, provided it lies outside the farm footprint. Towns (at least 200 ha built up in 2000) stay in the sample, since they are likely sources of farm labour; because they extend over several kilometres, a town is treated only if most of its built-up area lies within 10 km of a farm at entry.[8] Appendix Figure A.4.1 maps the treated and control settlements and the areas we exclude.

For each estimate, we reassign treatment at the level at which it is assigned: in each of 999 draws, as many clusters as there are treated farms are drawn at random from all farm and commune clusters of the sample, and they receive the entry years of the actual treated clusters of similar size (MacKinnon and Webb 2020). The ATT p-value is the share of draws in which the absolute t-statistic of the ATT is at least as large as the estimated one; the pre-trend p-value is computed in the same way for the joint Wald statistic that the coefficients for $e = -8, \ldots, -2$ are zero.

[8] This rule binds only for Saint-Louis: the outer edge of its 1 km zone comes within 10 km of a farm in 2004, but none of its built-up cells do, so it is dropped like any settlement 10–15 km from a farm. Thiès town (70 percent of its built-up cells within 10 km at entry) and the north-eastern extension of Saint-Louis (100 percent) are treated. For the same reason, the motorway, mine and excluded-farm rules apply to towns cell by cell: the affected cells are removed from a town's zone rather than dropping the town.

4.3 Census

We use the census to examine population, living standards, and employment at the commune level. We define a common cohort of communes exposed to commercial-farm expansion between 2002 and 2013. For population dynamics and household wealth, we apply the same Callaway and Sant'Anna (2021) estimator as for the spatial event studies, using all three census waves to estimate changes between 2002 and 2013 and between 2002 and 2023. For employment, we instead estimate first differences between 2002 and 2013.

To keep the census analysis as comparable as possible to the settlement design, we define treatment using the same underlying notion of local exposure to a commercial farm. In the settlement analysis, treatment is defined precisely by distance: settlements located 350 m to 10 km from a farm are treated. At the commune level, we cannot reproduce this distance band exactly because communes differ substantially in size and shape. This is particularly relevant across clusters, since communes are generally much smaller in the densely populated Thiès region than in the SRV. We therefore classify a commune as treated if it contains a settlement that is treated under the settlement definition. The resulting treatment indicator should thus be interpreted as capturing commune-level exposure to commercial farming within approximately 10 km, rather than as an exact 10 km spatial treatment.

We exclude the wider Dakar area and communes in which large-scale commercial farms were already established before 2002. In Thiès, we also exclude the department of Mbour (except its northern Sindia commune). This leaves us with 5 treated communes in the SRV and 11 in Thiès. The comparison group consists of never-treated communes outside the production clusters; communes first treated between 2013 and 2023, and communes within 10 km of another cluster's farms, are excluded from the comparison group. Appendix Figure A.4.2 shows the treated and never-treated communes in both samples.

For employment outcomes, we estimate

$$\Delta Y_c = Y_{c,2013} - Y_{c,2002} = \alpha + \beta D_c + \varepsilon_c, \tag{1}$$

where ΔY_c is the change in outcome Y in commune c between 2002 and 2013, and D_c indicates that the commune is treated. Under the assumption that, in the absence of farm expansion, outcomes in treated and comparison communes would have changed in parallel between 2002 and 2013, β is the average effect of farm expansion on the treated communes. Because farms may have arrived at any point between 2002 and 2013, β averages over communes with different lengths of exposure to large-scale commercial farms, of up to eleven years. We therefore interpret these as medium-run effects.

The wealth and employment regressions are weighted by the commune population aged 25–54 in 2002; for outcomes by sex, we use the corresponding same-sex population. This gives greater weight to changes affecting larger populations, particularly relevant for employment when the potential labor supply is distributed across communes of different sizes. Population and in-migration regressions are instead unweighted to capture average proportional changes across communes. We report results under the alternative weighting schemes in the Appendix.

For the census estimates, we randomly reassign the treatment indicator across the communes of each estimation sample 1,000 times, holding the number of treated communes fixed, and compute the share of draws in which the absolute t-statistic is at least as large as the estimated one. Given the small number of treated communes and the limited pre-treatment information available in the census, we interpret the census results cautiously. We treat them as evidence on the channels through which local economies adjust to commercial farming, rather than as stand-alone causal estimates.

4.4 Addressing Non-Random Placement

Commercial farms locate where land is available and suitable, where access to water is given, and where roads and markets are close. These same factors shape local economic development and Table 1 shows that treated and comparison communes differ systematically before farms arrive. While the difference-in-differences design removes all time-invariant differences between treated and comparison places, farms may enter places on different trajectories or alongside other changes, such as new roads or peri-urban growth.

We take three complementary steps to assess and limit these concerns – none of which is sufficient on its own. First, we examine eight years of pre-treatment coefficients in the spatial event studies to assess whether treated areas were already evolving differently, reporting where these coefficients are not flat.

Second, we exclude areas where other sources of economic change could confound our estimates. We exclude areas exposed to commercial farms already operating at baseline and, in the spatial analyses, mine and quarry footprints. In Thiès, proximity to Dakar and rapid coastal growth require further restrictions, applied to both treated and comparison units. We exclude the Dakar, Pikine, Guédiawaye and Rufisque departments, all areas within 50 km of Dakar-Plateau or 10 km of Blaise Diagne International Airport, and the communes of Diender Guedji and Keur Moussa. In the spatial event studies, we also exclude all cells crossed by the new motorways between Dakar, the airport, Thiès and Mbour and between Thiès and Touba. We further exclude areas within 10 km of the seven farms in the expanding urban

area around Yène, Rufisque and the airport, as well as the Petite Côte (Mbour department except Sindia) and Tattaguine, which is exposed only to farms in Mbour. The Petite Côte has experienced substantial tourism-related urbanization and electrification, and parts of Mbour receive electricity from a private concessionaire rather than SENELEC, complicating attribution of lighting changes to commercial farms.[9]

Third, we assess the sensitivity of our results to remaining potential confounders. Because large-scale mining can itself generate substantial changes in nearby economic activity (Kotsadam and Tolonen 2016), we assess the robustness of the nighttime-light and settlement results to excluding all observations within 5 km of a mine or quarry. To address the airport more directly, we re-estimate the nighttime-light event study for Thiès over the period 2000 to 2015, before the airport opened in December 2017.

5 Results

We present our main findings in three steps. We first examine the land-use change on the farms' footprint. This allows us to validate the onset of commercial farming, which is a necessary precondition for the analyses that follow. It also shows whether farms brought new land into cultivation or took over land that was already farmed, and thereby characterizes the nature of the shock in each cluster. We then turn to the spatial event studies of changes in the areas surrounding the farms, focusing on nighttime lights and settlement growth. Finally, we use the censuses to examine changes in population, wealth, and employment. We estimate effects separately for the different production clusters throughout.

5.1 Agricultural Land Use

Farm footprint. Figure 4 reports event-study estimates for 500 m grid cells located within 350 m of a commercial farm. These treated cells are compared with never-treated cells located 15–40 km from any commercial farm, restricting the comparison to control cells whose nearest farm belongs to the same cluster as the treated cells. We investigate land-use change using two outcomes, the annual cropland share and dry-season NDVI. The reported ATT averages the event-time effects over the first nine years after establishment.

In the SRV and Thiès, at least one of the two outcomes changes sharply at the recorded establishment date, after largely flat pre-treatment coefficients. This provides a useful vali-

[9]Because the farm-footprint outcomes measure land use on the farm itself, the restrictions above, which address urban growth and electrification near the farms, apply only to the nighttime-light and settlement analyses; for the footprint estimates we exclude only mine and quarry footprints, the surroundings of the two pre-2000 farms, and, in Thiès, the Dakar–airport corridor and the Yène and airport farms.

dation of the timing in our farm data. It also reveals that commercial-farm entry represents quite different land-use transitions in the two regions.

In the SRV, the cropland share rises by 15.4 percentage points ($p = 0.001$) and dry-season NDVI by 0.033 ($p = 0.002$).[10] Most of the increase occurs within the first two to three years. Farms in the SRV therefore brought new land under irrigated cultivation, in an area previously used mainly for grazing, fishing and flood-recession agriculture (Rasmussen et al. 1999; Cesaro et al. 2023). This conversion appears to start shortly before farms show up in our annual boundaries. Our pre-entry estimates are flat until about three years before entry and then rise, most likely as land is cleared and prepared for cultivation.[11] Still, a joint test of the pre-entry coefficients does not reject the null of no pre-trend ($p = 0.984$ for cropland, $p = 0.973$ for NDVI).

In Thiès, the annual cropland share falls slightly, by 1.7 percentage points ($p = 0.022$), while dry-season NDVI rises by 0.029 ($p = 0.012$). Together, these patterns suggest that commercial farms intensify existing farmland rather than bring new land into cultivation. This is consistent with accounts of commercial farms acquiring land from local farmers (Touré and Seck 2005). Some of the greening may reflect a shift towards tree crops, consistent with the increase in tree cover observed in the GLC_FCS30 data after farm entry (Appendix Figure A.2.1). But the estimated NDVI increase remains positive, at about two thirds of the pooled estimate ($p = 0.077$), among the five farms growing only annual horticultural crops (Appendix Figure A.2.2). This suggests that the greening may also reflect more intensive irrigated horticultural production.

In the Ferlo cluster, we find no change in either of our main outcomes. The annual cropland share and dry-season NDVI remain flat. This is not surprising. Acacia trees are a perennial woody crop, which the AFCD data do not classify as cropland, and the plantations are rain-fed, so we would not expect dry-season NDVI to respond strongly either. The right panel of Appendix Figure A.2.1 shows the GLC_FCS30D shrubland share, which is the land cover class closest to acacia plantations. It is flat before entry (pre-trend $p = 0.814$) and rises gradually afterwards, by 0.7 percentage points on average ($p = 0.013$) and by about 1.4 percentage points after eight years. However, distinguishing newly planted acacia from pre-existing sparse woody and shrub vegetation is difficult in this semi-arid environment, particularly as young acacia trees may not be detectable as changes in land cover. We

[10] We report average treatment effects on the treated (ATT) estimates throughout the text in this section, unless stated otherwise.

[11] A negative pre-entry coefficient means that treated cells were further below their level in the year before entry ($e = -1$) than control cells were, i.e. they grew faster than controls between that year and entry. Because the coefficients are flat until about $e = -4$ and only rise towards zero thereafter, this faster growth is concentrated in the years immediately before entry.

therefore do not interpret the absence of a response in our main satellite outcomes as evidence that little land conversion took place. Our mapped farm boundaries clearly show that the plantations themselves expanded to roughly 16,800 hectares by 2023.

Finally, in the southeastern cluster, neither the cropland share nor dry-season NDVI provides clean evidence of a change at farm entry. Dry-season NDVI rises, but the pre-treatment coefficients are erratic (pre-trend $p = 0.067$), so we are cautious in interpreting the post-treatment increase.

For the two horticultural clusters, the footprint estimates therefore reveal two distinct shocks. In the SRV, commercial farms bring land previously used much less intensively into irrigated cultivation. In Thiès, farms take over and intensify land that smallholders were already cultivating. This distinction is important because similar amounts of commercial horticulture, and labor demand of a similar scale, may generate different net changes in local production and employment depending on what the farms replace.

Spatial spillovers in land use. Figure A.2.3 in the Appendix shows how the annual cropland share changes in four disjoint rings around the farm. In the SRV, we restrict treated and control cells to those within 20 km of surface water, so that the comparison is limited to land that could in principle be irrigated. We find little evidence that commercial-farm entry leads to additional cropland expansion. The point estimate is positive within 4 km of the farms and becomes smaller with distance, reaching approximately zero in the outer rings. This pattern is consistent with some cultivation spreading to land directly adjacent to the farms, for instance where smallholders gain access to nearby irrigation infrastructure. However, none of the ring estimates is statistically significant, so we do not interpret this as clear evidence of spillovers. In Thiès and the southeastern cluster, the estimates are close to zero in all rings. In the Ferlo cluster, the estimates are small and slightly positive in the outer rings. Since they do not decline with distance from the farms, they are unlikely to reflect localized cropland spillovers from the plantations.

5.2 Local Economic Activity

We next ask whether the commercial farms affect areas surrounding them beyond agricultural land use. Our main spatial outcome is the extensive margin of nighttime light, that is, whether previously dark areas become lit. An increase in light could reflect greater concentration of population and economic activity, but it could also reflect improved electricity access or more intensive electricity use in existing settlements. We therefore first document the broader nighttime-light response and then ask whether it is accompanied by physical

expansion of settlements that were already present before the farms arrived.

Nighttime luminosity. Appendix Figure A.3.1 shows nighttime lights around the farms in each cluster in 2000, 2010, and 2020. Two features stand out. First, the areas around the farms in the Ferlo and the southeastern clusters remain almost completely dark throughout the entire period. Second, in Thiès, light is concentrated in discrete pockets around the farms rather than on the farm footprints themselves, and these lit areas expand visibly between 2010 and 2020. Part of this increase reflects the growth of the Dakar region and urban areas along the coast. In our estimates, we therefore exclude the wider Dakar area, the motorways, the area around the new airport, and the farms located within the expanding urban areas (see Section 4.4).

Because most rural areas in our sample are dark, we measure nighttime light as the share of area that is lit. Figure 5 reports event-study estimates for 500 m cells located between 350 m and 10 km from a farm, compared with never-treated cells 15–40 km away. In Thiès, the share of lit area increases by 9.9 percentage points after a farm arrives ($p = 0.002$). The effect builds up gradually and reaches around 12 percentage points six to eight years after entry. The pre-treatment coefficients are slightly negative but small, and we cannot reject that they are jointly zero ($p = 0.374$). In the SRV, Ferlo, and southeastern clusters, we find no comparable change within 10 km of the farms. The estimates are close to zero and not statistically significant in any of the three clusters.

The Thiès pattern is robust to several checks. Appendix Figure A.3.2 shows that the effect is positive across all cumulative treatment radii and becomes larger and more precisely estimated as the radius expands, from 5.7 percentage points within 4 km to 9.9 percentage points within 10 km. This pattern is consistent with the maps in Appendix Figure A.3.1, where increases in light appear in pockets in the vicinity of farms rather than on the farms themselves.[12] Table A.5.1 reports further checks. The Thiès estimate hardly changes when we widen the control group to cells 15-50 km or 15-60 km from the nearest farm (9.7 and 10.2 percentage points). Dropping all cells within 5 km of a mine or quarry removes about 40 percent of the treated cells, but the effect remains at 7.4 percentage points ($p = 0.003$). Restricting the period to 2000 to 2015, before the new airport opened, gives an effect of 8.5 percentage points ($p = 0.006$). Excluding the town of Thiès gives 10.5 percentage points ($p = 0.003$). When we add the Mbour communes back to the sample as treated, the estimate is somewhat smaller but remains clearly positive (6.2 percentage points, $p = 0.008$). In the

[12] In the SRV, the estimates for the narrower radii are negative and statistically significant: −2.8 percentage points within 4 km ($p = 0.001$), −2.2 within 6 km ($p = 0.002$) and −1.3 within 8 km ($p = 0.036$). The pre-treatment coefficients in these bands are jointly insignificant (pre-trend $p = 0.421$, 0.376 and 0.301).

SRV, the estimate remains small and not statistically significant at the 5 percent level across all control groups and when we drop cells near mines.

The nighttime light results therefore show a clear increase in the share of surrounding area that is lit after farm entry in Thiès, but not in the other clusters. The absence of a response in the Ferlo and southeastern clusters should nonetheless be interpreted with care. Our outcome captures only changes in economic activity that generate detectable nighttime lighting, and may therefore miss activity in these largely unlit areas.

The contrast between the SRV and Thiès is more informative. Despite commercial horticulture of similar scale and labor demand in the two regions, only Thiès shows a clear nighttime-light response. This suggests that labor-intensive horticulture alone may not be sufficient to generate broader local effects, and points to a possible role for the surrounding economic environment: Thiès is denser and better connected to markets and infrastructure than the SRV. We therefore focus the remainder of the analysis primarily on these two horticultural clusters.

Settlement growth. What accounts for the increase in nighttime-light coverage in Thiès? One possibility is that commercial farms attract population and economic activity towards nearby places, causing existing settlements to expand. To examine this possibility, we track the expansion of settlements already present in 2000, using the sample defined in Sections 3.2 and 4.2. Appendix Figure A.4.1 shows the resulting samples.

Figure 6 shows the results for the SRV and Thiès. In contrast to the nighttime-light results, we find only modest changes in the physical size of existing settlements. In the SRV, the built-up share of the settlement zone rises by 0.05 percentage points, but the estimate is imprecise ($p = 0.350$). In Thiès, the built-up share rises gradually after farm entry, by 0.25 percentage points on average and by about 0.4 percentage points after eight years, but this estimate is also imprecise ($p = 0.111$). In the SRV, the pre-treatment coefficients are close to zero and jointly insignificant ($p = 0.608$). In Thiès, they are individually small but jointly significant at the 10 percent level ($p = 0.077$).[13] The pattern of limited settlement growth is stable across the checks in Appendix Table A.5.1.

Taken together, the NTL and settlement results show a clear increase in nighttime-light coverage around farms in Thiès, but only modest physical expansion of existing settlements. The lighting response therefore appears unlikely to be driven mainly by the outward spread of pre-existing settlements. It could instead reflect more intensive activity within existing

[13] In Thiès, all seven pre-entry coefficients are small and individually insignificant: none exceeds 0.04 percentage points in absolute value, compared with an average post-entry effect of 0.25 percentage points, and the largest t-statistic is -1.5 (at $e = -2$).

places or faster extension of electricity to previously unlit areas. Village electrification records help distinguish between the two. Appendix Figure A.3.3 links the treated cells in Thiès to the government register of localities and the year each was connected to the grid. Among cells whose night-light pixel already contained a connected village in the year before entry, the share of area lit rises by about 30 percentage points relative to control cells connected by the same year ($p = 0.019$). In contrast, the share of cells containing a connected village rises by only about one percentage point, and this estimate is imprecise. The figures suggest that part of the increase in nighttime luminosity therefore occurs in places that were already on the grid. This is consistent with more intensive electricity use in already-connected areas, although additional grid connections may also contribute.

5.3 Population, Living Standards, and Employment

We now turn to the census to examine changes in population, living standards, and employment. The 2023 census is particularly useful for tracing longer-run adjustments, including population movements that may respond gradually to new economic opportunities.

Population dynamics. Table 2 shows how the communes exposed to commercial-farm expansion between 2002 and 2013 evolve across the subsequent census waves. In the SRV, working-age population changes little by 2013 (0.063 log points, $p = 0.295$), but is 0.259 log points higher by 2023 ($p = 0.002$). Cross-regional in-migration also changes little by 2013 (-0.222, $p = 0.368$) and is 0.543 log points higher by 2023, although this estimate is imprecise ($p = 0.174$). In Thiès, working-age population likewise changes little by 2013 (0.028 log points, $p = 0.783$), before rising by 0.193 log points by 2023 ($p = 0.073$). Cross-regional in-migration changes little by 2013 (0.178 log points, $p = 0.285$), but rises by 0.795 log points by 2023 ($p = 0.002$). Thus, by 2023, the population estimate is positive in both regions, while the in-migration estimate is positive in both but precisely estimated only in Thiès.[14] The estimated population and in-migration effects are not statistically distinguishable across the two regions, although these comparisons are imprecise given the small number of treated communes, particularly in the SRV (Appendix Table A.8.2).

Household wealth. NTL is a commonly used proxy for economic activity, not household living standards. As a complementary measure, Table 3 reports changes in a household wealth index and its components through 2023. In Thiès, wealth increases by 0.35 standard deviations more in exposed than comparison communes by 2013 ($p = 0.001$), and the estimate

[14] Our in-migration measure is coarse because it only captures moves across regional boundaries.

remains positive at 0.43 standard deviations in 2023 ($p = 0.031$). In 2013, the corresponding estimates are 9.6 percentage points for electric lighting ($p = 0.092$), 11.7 percentage points for flush toilets ($p = 0.023$), 14.9 percentage points for television ownership ($p = 0.006$), and 3.4 percentage points for car ownership ($p = 0.013$). By 2023, the individual component estimates are generally less precise, with the exception of car ownership, for which the estimate is 11.1 percentage points ($p = 0.001$). In the SRV, the wealth estimate is 0.17 standard deviations in 2013 ($p = 0.052$), but falls close to zero by 2023 (0.011, $p = 0.875$). The estimate is larger in Thiès in both periods, with a significant cross-region difference in 2013 ($p = 0.017$) and a less precise difference in 2023 ($p = 0.089$; Appendix Table A.8.2). Overall, the census evidence points to a more persistent positive association with household wealth in Thiès, consistent with the nighttime-light response there.

Employment. Tables 4 and 5 report changes in the employment rate and in the sectoral composition of employment, separately for women and men. We first focus on the Thiès region (Table 4), where neither women's nor men's overall employment rate changes significantly. The sectoral estimates are also mostly imprecise, so we focus on their signs and magnitudes where they exhibit a coherent pattern. Among employed women, the share working in crop agriculture increases by 8.9 percentage points ($p = 0.157$), a sizeable point estimate consistent with the high demand for female labor on horticultural farms documented in Section 2. At the same time, women's employment share in other services rises by 3.5 percentage points ($p = 0.039$), while the manufacturing estimate is also positive but imprecise. For men, there is little evidence of a change in crop agriculture or manufacturing, but transport rises by 2.3 percentage points ($p = 0.084$).

Table A.8.1 in the appendix provides more detail on the non-farm activities behind these shifts. Among women, employment in education and health rises by 2.3 percentage points ($p = 0.023$), while hairdressing and beauty services rise by 1.6 percentage points ($p = 0.106$). Tailoring and garment work also has a positive point estimate, although it is more imprecisely estimated. For men, the corresponding estimates are generally small and imprecise. With little evidence of a change in the overall employment rate, these patterns suggest adjustments in women's employment composition, including positive estimates for both crop agriculture and several service activities.

The Thiès estimates are therefore suggestive of adjustments along several of the margins highlighted in Section 2. Beyond the positive crop-agriculture estimate for women, the positive estimate for men's transport share is consistent with possible product-market linkages, while the increase in women's services share points towards a potential local-demand

response.

In the SRV, the largest employment-composition estimate is again for women in crop agriculture, whose share rises by 10.6 percentage points ($p = 0.079$). With only five treated communes, however, this estimate should be interpreted cautiously. Men's crop-agriculture share changes little (0.7 percentage points, $p = 0.843$). As in Thiès, the female point estimate is substantially larger than the male estimate, a pattern that accords with our farm-survey evidence of high female labor demand in horticulture. The female crop-agriculture estimates are also close in magnitude across the two regions, and the cross-region comparison is too imprecise to draw conclusions about whether they differ ($p = 0.756$; Appendix Table A.8.2).

The estimates for the remaining sectors are mostly imprecise. Among men, the trade share has a positive point estimate of 2.5 percentage points ($p = 0.249$), but this provides limited evidence of a change.

Appendix Table A.8.8 reports population and in-migration estimates weighted by baseline population. For population, weighting increases the 2013 point estimates, particularly in the SRV, but reduces the 2023 estimates and weakens the statistical evidence for population growth. The 2023 in-migration estimates also become smaller, although the estimate in Thiès remains statistically significant. Appendix Tables A.8.6 and A.8.7 show that the broad employment patterns are qualitatively similar when communes are weighted equally rather than by baseline population, although magnitudes and precision differ. The wealth results (Table A.8.5) remain strongly positive in Thiès under equal weighting, with larger estimates in both periods. In the SRV, however, the unweighted wealth estimates are smaller and imprecise, and turn negative by 2023.

As an alternative to the binary treatment definition used in the main census results, Tables A.8.3 and A.8.4 relate changes in employment outcomes to the change in commercial-farm hectares within 10 km between 2002 and 2013. Coefficients therefore give the change in the outcome associated with an additional 1,000 hectares of commercial-farm expansion. The broad patterns are similar to those in the binary specification. In Thiès, women's crop-agriculture, manufacturing, and other-services employment shares have positive coefficients, while men's crop-agriculture share has a negative coefficient and manufacturing and transport have positive coefficients. In the SRV, women's crop-agriculture share is again positive, while most other estimates are small and imprecise. Overall, the continuous-treatment estimates are broadly similar in direction to the main results, but are generally imprecisely estimated and should be viewed as a sensitivity check.

In summary, the census evidence complements our satellite results. Despite substantial sampling uncertainty, the employment estimates show some common patterns across the two

horticultural regions. In both, the crop-agriculture employment-share point estimates are substantially larger for women than for men, although we do not formally test the gender differences. By 2023, the working-age population estimates are positive in both regions, with stronger statistical evidence in the SRV, while cross-regional in-migration estimates are positive in both but precisely estimated only in Thiès. The strongest evidence of a difference between the regions is in household wealth: the positive wealth estimate persists through 2023 in Thiès but not in the SRV. Thiès also shows a rise in women's employment in other services and a positive estimate for men's transport, suggestive of the local-demand and product-market channels discussed in Section 2.

6 Conclusion

Whether large-scale commercial agriculture can stimulate rural development in sub-Saharan Africa remains a central question. Governments and development agencies promote commercial farming to bring capital and technology into agriculture and create rural employment, but concerns about displacement and uneven gains persist. Most existing analyses build on household surveys of workers, or on single production systems. Evidence on how commercial farming affects surrounding local economies, and how these effects differ across production systems, remains limited.

In this paper, we contribute such evidence from Senegal, where commercial farming has expanded substantially since 2000. We construct a new spatial census of all commercial farms larger than 200 hectares, tracing their boundaries annually from 1999 to 2023. We link these data to annual satellite-based measures of land cover, vegetation, settlements, and NTL, as well as to three population censuses. This allows us to examine changes on farm footprints and in surrounding local economies across four production systems differing in prior land use, crop mix, labor intensity, and economic geography.

Our analysis illustrates two central points. First, commercial farming can shape land use in different ways. In the SRV, land previously used for grazing, fishing, and flood-recession agriculture is brought under irrigated cultivation. In Thiès, by contrast, farms take over and intensify existing smallholder farmland rather than expand cultivated area. The effect of commercial farming on local production is therefore far from uniform, since the farms displace different activities in different clusters.

Second, local economic responses differ across the two horticultural regions. Both show positive, though imprecisely estimated, changes in women's crop-agriculture employment shares. Beyond this common pattern, we find the strongest evidence of broader economic

change in Thiès. Here, nighttime-light coverage rises gradually and persistently, while pre-existing settlements expand only modestly. We find no comparable nighttime-light response within 10 km of the farms in the SRV, Ferlo, or southeast. For Thiès, census comparisons also show a positive association with household wealth that persists through 2023. Cross-regional in-migration also rises, alongside an increase in women's other-services employment share and a positive, but less precisely estimated, change in men's transport share. In the SRV, working-age population is also higher by 2023, but evidence of changes in household wealth and non-farm employment is weaker. The Thiès results are consistent with labor-intensive production interacting with a denser, better-connected local economy to support wider economic activity. While our data cannot isolate the underlying channels, the contrast with the SRV suggests that the surrounding economic environment may play an important role.

These findings suggest that commercial-farm expansion does not automatically translate into broader local economic development. Investments of comparable scale and labor demand can be associated with very different local outcomes. Development policies promoting commercial agriculture should therefore consider both farms' production models and their potential linkages with surrounding labor, goods, and service markets. This calls for a farm- and place-sensitive approach to investment promotion, rather than assuming that attracting investment will itself generate broader development.

Our results also come with important caveats. Commercial farms are not placed at random. For the spatial outcomes, we compare treated areas with nearby areas within the same production cluster, examine pre-treatment dynamics, and exclude major potential confounders. The census comparisons involve fewer treated units and do not allow us to assess pre-treatment trends. Differential trends in the places investors choose therefore remain a concern, particularly in rapidly growing Thiès near Dakar. Nighttime lights are also an imperfect measure of economic activity, especially in the sparsely populated Ferlo and southeast, where the absence of a detectable response should not be interpreted as evidence that nothing changes. The focus on commercial farms larger than 200 ha also yields a limited sample, with few farms or treated communes in some clusters, reducing statistical power. Finally, our outcomes describe local economies rather than households. They show where activity rises, but not who benefits.

Future work linking our spatial farm data to household panels on income, consumption, assets, and land access could help identify who gains and who loses. Extending this approach to other countries could establish whether the patterns we document are specific to Senegal or more general features of commercial-farm expansion.

References

Anti, Sebastian, "Land Grabs and Labor in Cambodia," *Journal of Development Economics*, 2021, *149*, 102616.

Aremu, Olayinka, Anna Fabry, and Eva-Marie Meemken, "Farm size and the quality and quantity of jobs—Insights from Nigeria," *Food Policy*, 2024, *128*, 102731.

Bandiera, Oriana, Ahmed Elsayed, Andrea Smurra, and Céline Zipfel, "Young Adults and Labor Markets in Africa," *Journal of Economic Perspectives*, February 2022, *36* (1), 81–100.

Baumgartner, Philipp, Joachim Freiherr von Braun, Degnet Abebaw Ejigie, and Marc Müller, "Impacts of Large-scale Land Investments on Income, Prices, and Employment: Empirical Analyses in Ethiopia," *World Development*, 2015, *72* (C), 175–190.

Bergquist, Lauren Falcao, Benjamin Faber, Thibault Fally, Matthias Hoelzlein, Edward Miguel, and Andrés Rodríguez-Clare, "Scaling Agricultural Policy Interventions," *Econometrica*, 2026. Forthcoming.

Bishop, Menna, Niclas Moneke, and Céline Zipfel, "Blossoming Towns," HoSS Working Paper 2026-4, Stockholm School of Economics, Stockholm April 2026.

Bourgoin, Jeremy, Djibril Diop, Camille Jahel, Roberto Interdonato, and Quentin Grislain, "Beyond land grabbing narratives, acknowledging patterns and regimes of land control in Senegal," *Land Use Policy*, 2023, *131*, 106753.

Byerlee, Derek, Andres F. Garcia, Asa Giertz, and Vincent Palmade, *Growing Africa: Unlocking the Potential of Agribusiness*, Washington, DC: World Bank, 2013.

Callaway, Brantly and Pedro H. C. Sant'Anna, "Difference-in-Differences with multiple time periods," *Journal of Econometrics*, December 2021, *225* (2), 200–230.

Cesaro, Jean-Daniel, Dimitri S. Adjanohoun, Baba Ba, and Serena Ferrari, "Du conflit aux synergies : les relations complexes entre pasteurs et agro-industries dans la vallée du fleuve Sénégal," *Bulletin de l'Association de Géographes Français*, 2023, *100* (1), 38–57.

Chiovelli, Giorgio, Stelios Michalopoulos, Elias Papaioannou, and Tanner Regan, "Illuminating the Global South," *The Economic Journal*, 2026, *advance online publication* (ueaf134).

Christiaensen, Luc and Will Martin, "Agriculture, Structural Transformation and Poverty Reduction: Eight New Insights," *World Development*, 2018, *109*, 413–416.

Cisse, Abdoulaye, Alain de Janvry, Joel Ferguson, Marco Gonzalez-Navarro, Samba Mbaye, Elisabeth Sadoulet, and Mame Mor Anta Syll, "Irrigation infrastructure and satellite-measured land cultivation impacts: Evidence from the Senegal river valley," *Journal of Development Economics*, 2026, *179*, 103615.

Collier, Paul and Stefan Dercon, "African Agriculture in 50 Years: Smallholders in a Rapidly Changing World?," *World Development*, 2014, *63*, 92–101.

de Chaisemartin, Clément and Xavier D'Haultfœuille, "Two-Way Fixed Effects Estimators with Heterogeneous Treatment Effects," *American Economic Review*, September 2020, *110* (9), 2964–2996.

Deininger, Klaus and Derek Byerlee, "The Rise of Large Farms in Land Abundant Countries: Do They Have a Future?," *World Development*, April 2012, *40* (4), 701–714.

den Broeck, Goedele Van, Kaat Van Hoyweghen, and Miet Maertens, "Horticultural exports and food security in Senegal," *Global Food Security*, 2018, *17*, 162–171.

Dercon, Stefan and Douglas Gollin, "Agriculture in African Development: Theories and Strategies," *Annual Review of Resource Economics*, 2014, *6* (1), 471–492.

Didan, Kamel, "MODIS/Terra Vegetation Indices 16-Day L3 Global 250m SIN Grid V061," NASA Land Processes Distributed Active Archive Center [Dataset] 2021. Accessed 26 September 2026.

Energy Sector Management Assistance Program, "Maximisation des retombées de l'électricité en zones rurales: Application au cas du Sénégal," Technical Report 109/07 FR, World Bank, Washington, DC May 2007.

Engineering & Environment Services, "Plan de gestion environnementale et sociale du projet d'extension et de renforcement des réseaux MT et BT dans les régions: Commune de Diender," Rapport final, Ministère

du Pétrole et des Énergies, République du Sénégal, Dakar May 2019.

Fabry, Anna, Goedele Van den Broeck, and Miet Maertens, "Decent work in global food value chains: Evidence from Senegal," *World Development*, April 2022, *152*, 105790.

Fall, S. T., A. S. Fall, I. Cissé, A. Badiane, C. A. Fall, and M. Ba Diao, "Intégration horticulture-élevage dans les systèmes agricoles urbains de la zone des Niayes (Sénégal)," *Bulletin de l'APAD*, 2000, (19).

FAO, "Senegal Published the Annual Agricultural Survey 2019–2020 Report, Providing Data and Information on the Country's Agricultural Sector," Food and Agriculture Organization of the United Nations, AGRISurvey programme 2021. Accessed 26 October 2026.

Gáfaro, Margarita and Heitor S. Pellegrina, "Trade, Farmers' Heterogeneity, and Agricultural Productivity: Evidence from Colombia," *Journal of International Economics*, 2022, *137*, 103598.

Glover, Steven and Sam Jones, "Can commercial farming promote rural dynamism in sub-Saharan Africa? Evidence from Mozambique," *World Development*, 2019, *114*, 110–121.

Gollin, Douglas, "Agricultural Productivity and Structural Transformation: Evidence and Questions for African Development," *Oxford Development Studies*, 2023, *51* (4), 375–396.

_ , Margaret McMillan, Emmanuel Mensah, Gideon Ndubuisi, and Solomon Owusu, "Taking Stock of Africa's Economic Transformation: Rethinking Sources of Productivity Growth," *The World Bank Research Observer*, 2026, *41* (2), 269–308.

Goodman-Bacon, Andrew, "Difference-in-differences with variation in treatment timing," *Journal of Econometrics*, 2021, *225* (2), 254–277.

Haggblade, Steven, Peter Hazell, and Thomas Reardon, "The Rural Non-farm Economy: Prospects for Growth and Poverty Reduction," *World Development*, 2010, *38* (10), 1429–1441.

Jayne, T. S., Ayala Wineman, Jordan Chamberlin, Milu Muyanga, and Felix Kwame Yeboah, "Changing Farm Size Distributions and Agricultural Transformation in Sub-Saharan Africa," *Annual Review of Resource Economics*, 2022, *14*, 109–130.

Kassie, Workineh Asmare, Yeshwas Admasu, Dagim Belay, Solomon Zena Walelign, and Jipeng Zhang, "Large-scale land acquisitions in Ethiopia: Impacts on agricultural productivity and deforestation," *Journal of Development Economics*, 2026, *183*, 103836.

Kotsadam, Andreas and Anja Tolonen, "African Mining, Gender, and Local Employment," *World Development*, 2016, *83* (C), 325–339. Publisher: Elsevier.

Lam, David and Ahmed Elsayed, *Labour Markets in Low-Income Countries: Challenges and Opportunities*, Oxford: Oxford University Press, 2021.

Lay, Jann, Kerstin Nolte, and Kacana Sipangule, "Large-scale farms in Zambia: Locational patterns and spillovers to smallholder agriculture," *World Development*, 2021, *140*, 105277.

_ , Ward Anseeuw, Sandra Eckert, Insa Flachsbarth, Christoph Kubitza, Kerstin Nolte, and Markus Giger, "Taking Stock of the Global Land Rush: Few Development Benefits, Many Human and Environmental Risks," Land Matrix Analytical Report III, Centre for Development and Environment, University of Bern; CIRAD; GIGA; University of Pretoria 2021.

Lou, Zihang, Dailiang Peng, Zhou Shi, Hongyan Wang, Ke Liu, Yaqiong Zhang, Xue Yan, Zhongxing Chen, Su Ye, Le Yu, Jinkang Hu, Yulong Lv, Hao Peng, Yizhou Zhang, and Bing Zhang, "An annual cropland extent dataset for Africa at 30 m spatial resolution from 2000 to 2022," *Earth System Science Data*, 2025, *17* (8), 3777–3805.

MacKinnon, James G. and Matthew D. Webb, "Randomization Inference for Difference-in-Differences with Few Treated Clusters," *Journal of Econometrics*, 2020, *218* (2), 435–450.

Maertens, Miet and Ellen Verhofstadt, "Horticultural exports, female wage employment and primary school enrolment: Theory and evidence from Senegal," *Food Policy*, 2013, *43*, 118–131.

_ and Johan F.M. Swinnen, "Trade, Standards, and Poverty: Evidence from Senegal," *World Development*, 2009, *37* (1), 161–178.

McMillan, Margaret and Albert Zeufack, "Labor Productivity Growth and Industrialization in Africa," *Journal of Economic Perspectives*, 2022, *36* (1), 3–32.

Mercandalli, Sara, Perrine Burnod, Aurélien Reys, Ward Anseeuw, Markus Giger, Boniface

Kiteme, and A. Ravelo, "Nuancing narratives on labour market effects of large-scale agricultural investments in sub-Saharan Africa: Evidence from Kenya, Mozambique and Madagascar," in "2nd International Symposium on Work in Agriculture: Thinking the Future of Work in Agriculture" INRAE Clermont-Ferrand, France March 2021.

Ndiaye, Elhadji Mounirou, "L'approvisionnement des marchés et de la grande distribution en produits horticoles des Niayes," Research report, Initiative Prospective Agricole et Rurale (IPAR), Dakar September 2021.

Nolte, Kerstin and Martin Ostermeier, "Labour Market Effects of Large-Scale Agricultural Investment: Conceptual Considerations and Estimated Employment Effects," *World Development*, 2017, *98*, 430–446.

PACE Sénégal, "Cluster Tomate," Programme d'Appui à la Compétitivité de l'Afrique de l'Ouest 2024. Accessed 26 October 2026.

Raimondi, Valentina and Margherita Scoppola, "Foreign Land Acquisitions and Institutional Distance," *Land Economics*, 2018, *94* (4), 517–540.

Rasmussen, Kjeld, Niels Larsen, Frédéric Planchon, Jens Andersen, Inge Sandholt, and Sofus Christiansen, "Agricultural Systems and Transnational Water Management in the Senegal River Basin," *Geografisk Tidsskrift–Danish Journal of Geography*, 1999, *99*, 59–68.

Roth, Jonathan, "Interpreting Event-Studies from Recent Difference-in-Differences Methods," *The Japanese Economic Review*, 2026, *77* (2), 275–288.

_ , Pedro H. C. Sant'Anna, Alyssa Bilinski, and John Poe, "What's Trending in Difference-in-Differences? A Synthesis of the Recent Econometrics Literature," *Journal of Econometrics*, 2023, *235* (2), 2218–2244.

République du Sénégal, "Loi n° 2004-16 du 4 juin 2004 portant loi d'orientation agro-sylvo-pastorale," Journal officiel de la République du Sénégal, no. 6176, 14 août 2004, p. 1266 2004. Accessed 26 October 2026.

_ , "Programme d'Accélération de la Cadence de l'Agriculture Sénégalaise (PRACAS) Volet agricole du Plan Sénégal Emergent (PSE)," Government strategy document, Ministère de l'Agriculture et de l'Eau et des Ressources, Dakar August 2014.

Sonno, Tommaso and Davide Zufacchi, "Large-Scale Land Acquisitions: Trees, Trade and Structural Change," CEP Discussion Paper 2075 February 2025.

Sun, Liyang and Seth Abraham, "Estimating dynamic treatment effects in event studies with heterogeneous treatment effects," *Journal of Econometrics*, 2021, *225* (2), 175–199.

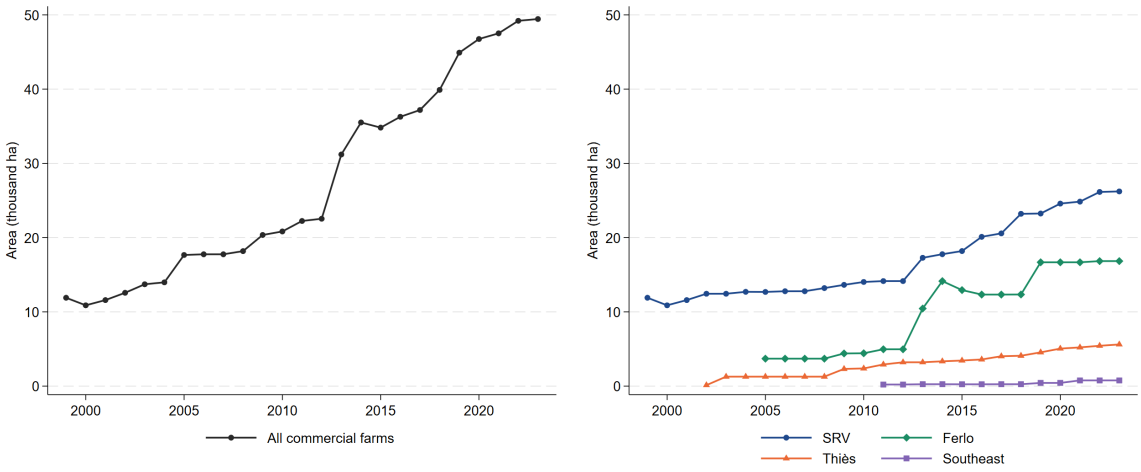
Touré, Oussouby and Sidy Mohamed Seck, "Family and Commercial Farming in the Niayes Area of Senegal," Drylands Issue Paper 133, International Institute for Environment and Development, London March 2005.

Van den Broeck, Goedele and Miet Maertens, "Moving Up or Moving Out? Insights into Rural Development and Poverty Reduction in Senegal," *World Development*, 2017, *99*, 95–109.

Zhang, Xiao, Tingting Zhao, Hong Xu, Wendi Liu, Jinqing Wang, Xidong Chen, and Liangyun Liu, "GLC_FCS30D: the first global 30 m land-cover dynamics monitoring product with a fine classification system for the period from 1985 to 2022 generated using dense-time-series Landsat imagery and the continuous change-detection method," *Earth System Science Data*, 2024, *16*, 1353–1381.

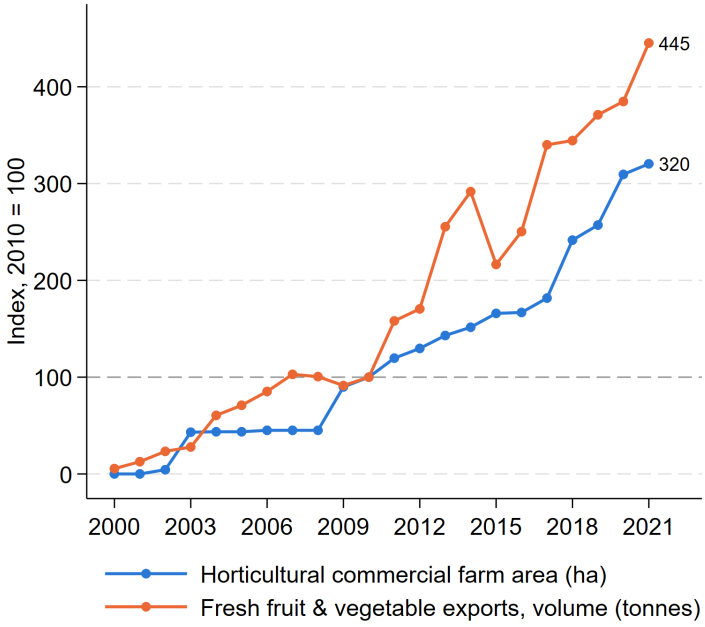
Figures

Figure 1: Expansion of commercial farming in Senegal between 1999 and 2023



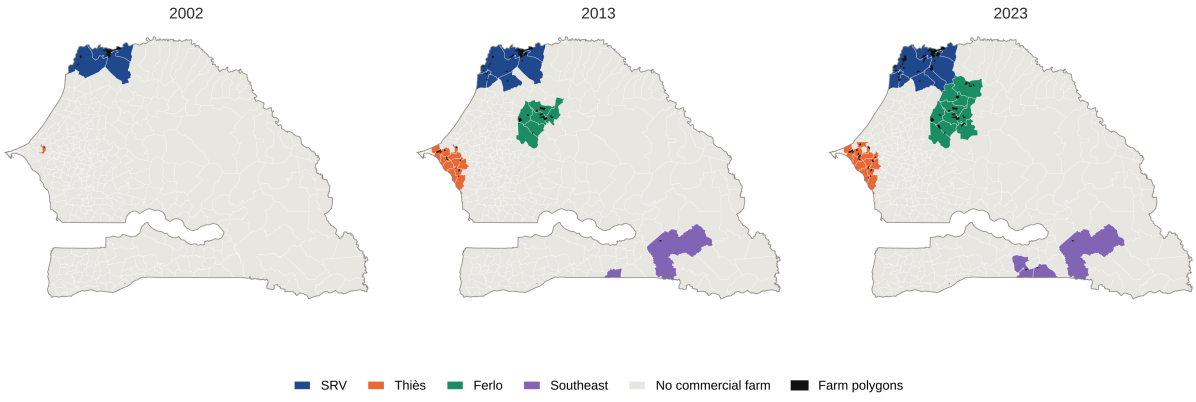
Notes: Total area of commercial farms in Senegal by year, in thousands of hectares. The left panel shows all farms together; the right panel splits the same total by crop cluster. SRV covers the Senegal River Valley farms (horticulture, sugar and rice), Thiès the horticultural farms of the Dakar and Thiès regions, Ferlo the gum arabic plantations and southeast the banana plantations. Farm area in each year is the sum of the farm polygons present that year based on our primary data on commercial farm expansion.

Figure 2: Horticultural commercial farm area and fresh fruit and vegetable exports, 2000–2021



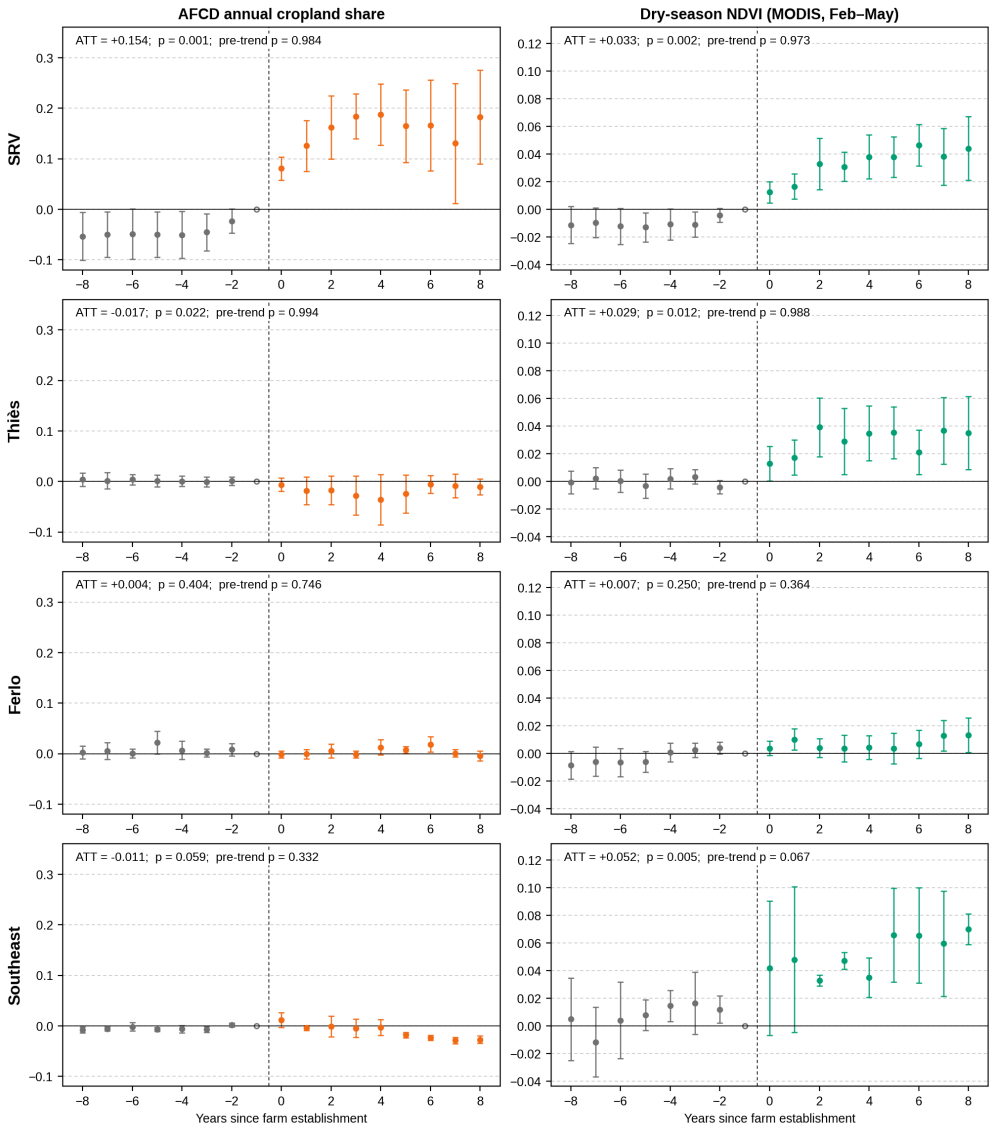
Notes: Both series are indexed to 2010 = 100. Farm area is the total area (ha) of commercial horticultural farms in each year: Thiès farms and high-labor-intensity farms in the Senegal River Valley. Ferlo (gum arabic), southeast (banana), sugar and rice farms are excluded. Exports are Senegal's fresh fruit and vegetable exports by volume (tonnes), HS 0701–0709 and 0804–0810, from UN Comtrade. Bananas (HS 0803) are excluded. The 2013 HS 0810 volume is dropped because of a unit-reporting error. The numbers at the right are the 2021 index values.

Figure 3: Commercial farms and crop clusters by census wave, 2002–2023



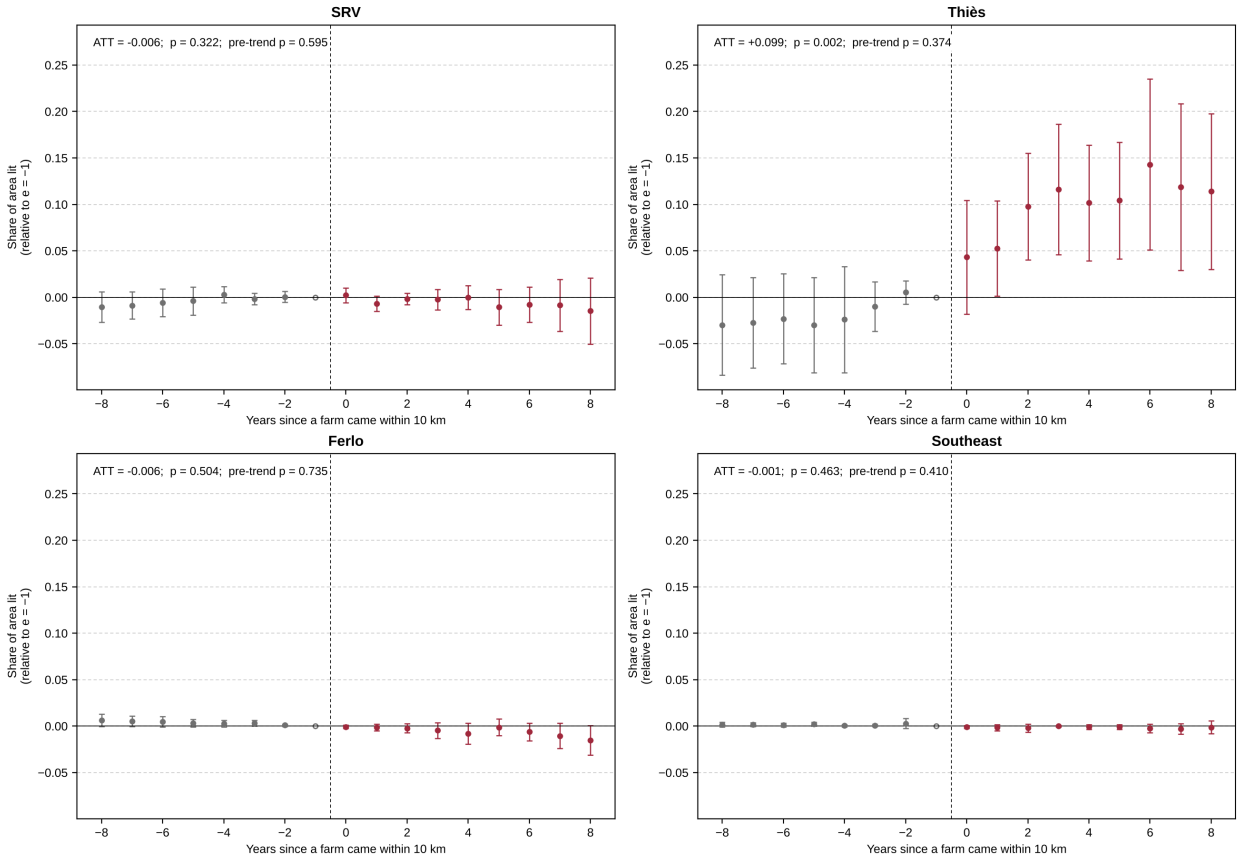
Notes: Communes (2002 boundaries) containing a commercial farm active in each census year, coloured by the crop cluster of that farm; black areas are the farm polygons mapped for that year. A commune reached by farms of two clusters is assigned the cluster with the larger buffer area. Grey communes have no farm within 2 km. No communes are excluded, so the map shows all communes near farms, not the estimation samples, which drop urban Dakar, the Dakar fringe and communes where farming was established before 2002 (Section 4.3).

Figure 4: Land-use change on the farm footprint



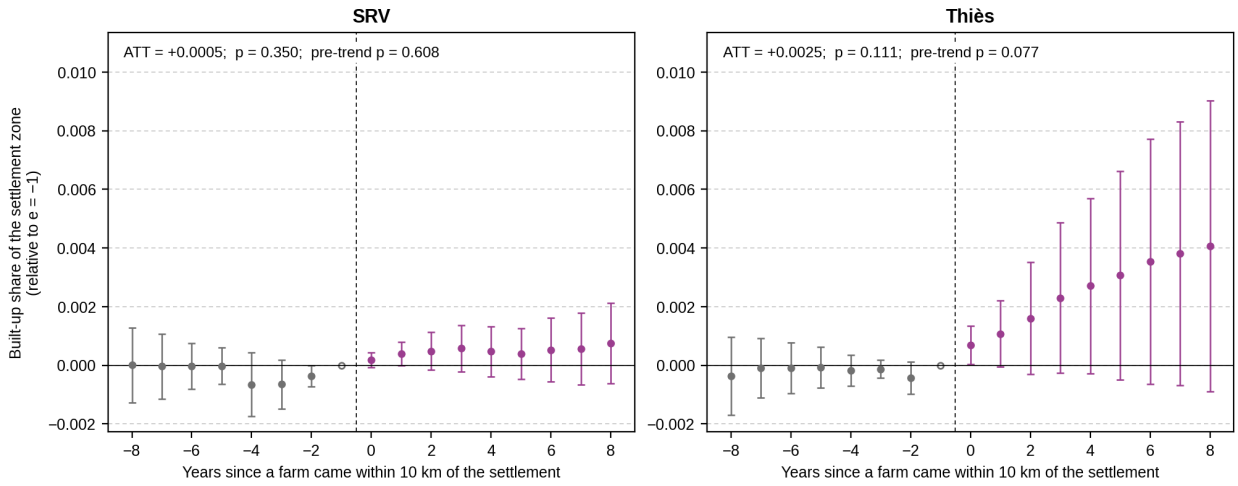
Notes: Outcomes: share of the cell classified as annual cropland (left) and dry-season (February–May) NDVI (right); units are 500 m grid cells on the farm footprint, i.e. within 350 m of a farm's maximum extent. Data: AFCD annual cropland and MODIS MOD13Q1 NDVI, 2000–2022. Restrictions: we drop cells within 2 km of the two farms operating before 2000, mine and quarry footprints and Richard Toll town; in Thiès, the Dakar–airport corridor and the Yène and airport farms. Treatment: entry is the first year a farm lies within 350 m of the cell (2002–2022); controls are never-treated cells 15–40 km from any farm whose nearest farm is in the same cluster. Observations: treated (control) cells: SRV 816 (18,581), Thiès 261 (15,712), Ferlo 1,183 (43,713), southeast 87 (33,112); treated cells lie near 12, 12, 11 and 3 farms. Estimation: Callaway and Sant'Anna (2021), never-treated controls, coefficients relative to $e = -1$; the ATT averages $e = 0, \ldots, 8$. Inference: ATT p-value from randomization inference on the ATT t-statistic (999 draws; MacKinnon and Webb 2020); pre-trend p-value from randomization inference on the joint Wald statistic that $e = -8, \ldots, -2$ are zero (999 draws); bars are 95% confidence intervals from a weighted cluster bootstrap (499 draws), clustered by farm for treated and by 2002 commune for control cells.

Figure 5: Nighttime light coverage before and after farm entry, 2000–2023



Notes: Outcome: share of area lit; units are 500 m grid cells, each taking the lit status (DN > 0) of the 1 km night-light cell it falls in. Data: harmonised night lights of Chiovelli et al. (2026), 2000–2023. Restrictions: we drop all mine footprints, the surroundings of the two pre-2000 farms and cells whose night-light pixel overlaps a farm; in Thiès, also the Dakar region, Diender Guedji and Keur Moussa, cells within 50 km of Dakar-Plateau or 10 km of the airport, motorway cells, cells within 10 km of the seven farms around Yène, Rufisque and the airport, the Petite Côte (Mbour department except Sindia) and Tattaguine. Treatment: cells 350 m–10 km from a farm's maximum extent, entry the first year a farm comes within 10 km (2002–2022); treated cells already within 15 km of a farm the year before entry are dropped. Controls: never-treated cells 15–40 km from the nearest farm, which is in the same cluster. Observations: treated (control) cells: SRV 9,264 (18,449), Thiès 2,727 (13,398), Ferlo 13,696 (43,713), southeast 3,894 (33,109), near 13, 9, 11 and 3 farms. Estimation: Callaway and Sant'Anna (2021), never-treated controls, coefficients relative to $e = -1$; the ATT averages $e = 0, \ldots, 8$. Inference: ATT p-value from randomization inference on the ATT t-statistic (999 draws; MacKinnon and Webb 2020); pre-trend p-value from randomization inference on the joint Wald statistic that $e = -8, \ldots, -2$ are zero (999 draws); bars are 95% confidence intervals from a weighted cluster bootstrap (499 draws), clustered by farm for treated and by 2002 commune for control cells.

Figure 6: Settlement growth near commercial farms



Notes: Outcome: built-up share of the settlement zone, excluding paved roads; units are settlements present in 2000 (clusters of 500 m cells with at least 5% built-up cover) together with every cell within 1 km. Data: GLC_FCS30D impervious surface, 2000–2022. Restrictions: we drop settlements touching a mine footprint or a motorway cell; in Thiès, also settlements within 50 km of Dakar-Plateau, in Diender Guedji and Keur Moussa, within 10 km of an excluded farm, in the Petite Côte or in Tattaguine (Figure A.4.1). Treatment: settlements 350 m–10 km from a farm, entry the first year a farm comes within 10 km (2002–2022); a town is treated only if at least half of its built-up area lies within 10 km; settlements already within 15 km of a farm the year before entry are dropped. Controls: never-treated settlements 15–40 km from the nearest farm, which is in the same cluster. Observations: SRV 60 treated settlements near 9 farms and 184 controls in 16 communes; Thiès 84 treated near 9 farms and 367 controls in 27 communes. Estimation: Callaway and Sant'Anna (2021), never-treated controls, coefficients relative to $e = -1$; the ATT averages $e = 0, \ldots, 8$. Inference: ATT p-value from randomization inference on the ATT t-statistic (999 draws; MacKinnon and Webb 2020); pre-trend p-value from randomization inference on the joint Wald statistic that $e = -8, \ldots, -2$ are zero (999 draws); bars are 95% confidence intervals from a weighted cluster bootstrap (499 draws), clustered by farm for treated and by 2002 commune for control settlements.

Tables

Table 1: Farm placement and baseline local conditions, by cluster

	(1) Never-treated mean	(2) Thiès	(3) SRV	(4) Ferlo	(5) Southeast
		Treated − never-treated (RI p-value)			
Geography and access					
Distance to Dakar Plateau (km)	259.4	−194.6	−52.3	−35.9	172.0
		(0.000)	(0.410)	(0.449)	(0.011)
Distance to the sea (km)	136.3	−109.9	−95.4	−14.3	98.2
		(0.003)	(0.060)	(0.732)	(0.092)
Distance to river or lake (km)	28.7	4.5	−21.5	0.5	−19.3
		(0.535)	(0.030)	(0.947)	(0.080)
Distance to 1992 primary road (km)	44.5	−33.9	−25.9	−26.2	69.2
		(0.088)	(0.473)	(0.312)	(0.054)
Satellite					
Wet-season peak NDVI, 2000–01	0.628	−0.062	−0.226	−0.017	0.171
		(0.126)	(0.000)	(0.691)	(0.007)
Dry-season NDVI, 2000–01	0.243	−0.019	−0.055	−0.041	0.071
		(0.331)	(0.049)	(0.054)	(0.030)
Share of lit 1 km cells, 2000–01	0.012	0.110	0.006	−0.009	−0.012
		(0.000)	(0.725)	(0.465)	(0.489)
Night-light trend, 1992–2002	0.003	0.014	0.003	−0.002	−0.003
		(0.000)	(0.189)	(0.505)	(0.441)
Census, 2002					
Log population density, 25–54	2.491	1.592	−0.138	−0.766	−0.671
		(0.000)	(0.788)	(0.044)	(0.214)
Wealth index	−0.589	0.256	0.223	−0.029	−0.141
		(0.002)	(0.043)	(0.715)	(0.150)
Electric lighting	0.086	0.147	0.157	0.022	−0.075
		(0.002)	(0.024)	(0.635)	(0.225)
Women in crop agriculture	0.661	−0.328	−0.471	−0.432	0.208
		(0.001)	(0.000)	(0.000)	(0.141)
Men in crop agriculture	0.565	−0.221	−0.323	−0.356	0.200
		(0.001)	(0.000)	(0.000)	(0.075)
In-migrant share, 25–54	0.097	0.007	0.011	−0.034	−0.015
		(0.787)	(0.758)	(0.191)	(0.728)
Observations					
Communes, treated		11	5	9	4
Communes, never-treated	263	263	263	263	263
500 m cells, treated		7,219	19,818	21,615	30,211
500 m cells, never-treated	636,975	636,975	636,975	636,975	636,975
1 km cells, treated		2,185	6,032	6,558	9,063
1 km cells, never-treated	192,135	192,135	192,135	192,135	192,135

Notes: Unweighted commune means. Column (1): the 263 never-treated communes of Tables 2–5, the same in every column. Columns (2)–(5): treated minus never-treated mean; RI p-values in parentheses (1000 reassignments of treatment within the cluster's sample, number treated fixed). Treated communes contain a settlement 350 m–10 km from a farm of the cluster, first reached in 2002–2013; the cluster's other communes within 10 km of its farms, and communes first reached after 2013, are excluded. Other exclusions and three-census balancing as in Tables 2–5. Distances to Dakar and to the 1992 primary road (Digital Chart of the World): from the commune centroid. Distances to the sea and to rivers (mean discharge ≥ 10 m^3/s) or lakes (HydroSHEDS), and NDVI (MODIS, 2000–01; wet-season peak, late July–October; dry-season mean, February–May): means over the commune's 500 m cells. Night lights (Chiovelli et al. 2026, 1 km cells): share of cells lit in 2000–01; OLS trend of log(1 + commune mean), 1992–2002. Census rows: 2002 10 per cent sample, variables of Tables 2–5 (log persons aged 25–54 per km^2; Table 3 wealth index; electric lighting; crop agriculture's share of classified employment aged 25–54, by sex; share aged 25–54 born in another region). Observation rows: communes and the 500 m and 1 km cells within them.

Table 2: Population and in-migrants, 2002–2023 dynamic effects

	Population		In-migrants	
	(1) SRV	(2) Thiès	(3) SRV	(4) Thiès
First census after entry	0.063	0.028	-0.222	0.178
	[0.049]	[0.084]	[0.182]	[0.151]
RI p-value (t)	0.295	0.783	0.368	0.285
Second census after entry (2023)	0.259	0.193	0.543	0.795
	[0.055]	[0.099]	[0.297]	[0.181]
RI p-value (t)	0.002	0.073	0.174	0.002
Never-treated mean, 2002	6.048	6.048	3.426	3.426
Observations	268	274	263	269
Treated communes	5	11	5	11
Total communes	268	274	268	274

Notes: Callaway and Sant'Anna (2021) estimates, never-treated controls, no covariates. Treated communes contain a settlement 350 m–10 km from a commercial farm (all treated by 2013). First row: $ATT(2013, 2013)$; second row: $ATT(2013, 2023)$. Thiès treated communes: Cherif Lo, Fandene, Mont Rolland, Ndiayene Sirah, Ngoudiane, Noto, Notto Gouye Diama, Sindia, Tassette, Thienaba, Thiès urbain. Excluded throughout: the Petite Côte (Mbour department except Sindia), Tattaguine, Touba Toul, Thiès-cluster communes within 50 km of the Dakar Plateau (except Sindia), urban Dakar and Rufisque, the SRV delta (Ronkh, Mbane, Gae), and communes inside another cluster's 10 km ring. Panel balanced on the three censuses. Standard errors clustered by commune in brackets; RI p-values from 1000 permutations of the cohort vector (t-statistic). Columns (1)–(2): log population aged 25–54; columns (3)–(4): log persons aged 25–54 born in another region of Senegal; both sexes. Unweighted. Communes with no in-migrants in a census drop from columns (3)–(4).

Table 3: Household wealth and housing quality, 2002–2023 dynamic effects

	Wealth index		Electric lighting		Flush toilet		Television		Car	
	(1) SRV	(2) Thiès	(3) SRV	(4) Thiès	(5) SRV	(6) Thiès	(7) SRV	(8) Thiès	(9) SRV	(10) Thiès
First census after entry	0.170	0.352	0.028	0.096	0.126	0.117	0.083	0.149	0.015	0.034
	[0.049]	[0.058]	[0.021]	[0.046]	[0.026]	[0.039]	[0.028]	[0.031]	[0.004]	[0.008]
RI p-value (t)	0.052	0.001	0.332	0.092	0.022	0.023	0.111	0.006	0.023	0.013
Second census after entry (2023)	0.011	0.432	-0.127	0.052	0.064	0.134	-0.002	0.134	0.051	0.111
	[0.045]	[0.139]	[0.041]	[0.111]	[0.029]	[0.068]	[0.034]	[0.075]	[0.005]	[0.015]
RI p-value (t)	0.875	0.031	0.089	0.754	0.184	0.141	0.966	0.165	0.001	0.001
Never-treated mean, 2002	-0.589	-0.589	0.086	0.086	0.086	0.086	0.087	0.087	0.025	0.025
Observations	268	274	268	274	268	274	268	274	268	274
Treated communes	5	11	5	11	5	11	5	11	5	11
Total communes	268	274	268	274	268	274	268	274	268	274

Notes: Callaway and Sant'Anna (2021) estimates, never-treated controls, no covariates. Treated communes contain a settlement 350 m–10 km from a commercial farm (all treated by 2013). First row: $ATT(2013, 2013)$; second row: $ATT(2013, 2023)$. Thiès treated communes: Cherif Lo, Fandene, Mont Rolland, Ndiayene Sirah, Ngoudiane, Noto, Notto Gouye Diama, Sindia, Tassette, Thienaba, Thiès urbain. Excluded throughout: the Petite Côte (Mbour department except Sindia), Tattaguine, Touba Toul, Thiès-cluster communes within 50 km of the Dakar Plateau (except Sindia), urban Dakar and Rufisque, the SRV delta (Ronkh, Mbane, Gae), and communes inside another cluster's 10 km ring. Panel balanced on the three censuses. Standard errors clustered by commune in brackets; RI p-values from 1000 permutations of the cohort vector (t-statistic). Household means, each household weighted equally. Weighted by 2002 commune population aged 25–54. Columns (1)–(2): wealth index, the first principal component of eighteen housing and asset indicators coded identically in the three censuses, loadings from never-treated households; in standard deviations of the 2002 distribution. Columns (3)–(10): shares of households with electric lighting, a flush toilet, a television, a car or truck.

Table 4: Employment outcomes: Thiès, 2002–2013

	(1) Working (/pop.)	(2) Crop agri.	(3) Other primary	(4) Manu-facturing	(5) Constr-uction	(6) Trans-port	(7) Trade	(8) Other services
	Panel A: Women							
Treated commune (0/1)	0.006	0.089	-0.000	0.018	-0.001	0.004	-0.069	0.035
	[0.020]	[0.042]	[0.004]	[0.011]	[0.001]	[0.003]	[0.043]	[0.012]
RI p-value (t)	0.766	0.157	0.956	0.292	0.473	0.322	0.291	0.039
Never-treated mean, 2002	0.327	0.661	0.026	0.036	0.002	0.001	0.214	0.047
Observations	274	272	272	272	272	272	272	272
Treated communes	11	11	11	11	11	11	11	11
Total communes	274	274	274	274	274	274	274	274
	Panel B: Men							
Treated commune (0/1)	0.045	-0.015	-0.005	0.008	-0.000	0.023	-0.001	-0.009
	[0.026]	[0.022]	[0.010]	[0.008]	[0.008]	[0.009]	[0.007]	[0.014]
RI p-value (t)	0.179	0.657	0.694	0.391	0.994	0.084	0.921	0.705
Never-treated mean, 2002	0.880	0.565	0.099	0.058	0.040	0.038	0.116	0.084
Observations	274	274	274	274	274	274	274	274
Treated communes	11	11	11	11	11	11	11	11
Total communes	274	274	274	274	274	274	274	274

Notes: First differences 2002–2013, one observation per commune, ages 25–54, by sex; robust standard errors in brackets. Never-treated communes as in Tables 2–3. Treated: the commune contains a settlement 350 m–10 km from a commercial farm by 2013. Column (1): employed over population of the same sex. Columns (2)–(8): shares of classified employment, sectors by occupation (unclassifiable records excluded from the denominator; domestic work included, not shown). RI p-values from 1000 permutations of the treatment indicator (t-statistic). Weighted by 2002 commune population aged 25–54 of the same sex. Sample: the Thiès cluster and the never-treated communes. Thiès treated communes: Cherif Lo, Fandene, Mont Rolland, Ndiayene Sirah, Ngoudiane, Noto, Notto Gouye Diama, Sindia, Tassette, Thienaba, Thiès urbain. Excluded throughout: the Petite Côte (Mbour department except Sindia), Tattaguine, Touba Toul, Thiès-cluster communes within 50 km of the Dakar Plateau (except Sindia), urban Dakar and Rufisque, the SRV delta (Ronkh, Mbane, Gae), and communes inside another cluster's 10 km ring.

Table 5: Employment outcomes: SRV, 2002–2013

	(1) Working (/pop.)	(2) Crop agri.	(3) Other primary	(4) Manu-facturing	(5) Constr-uction	(6) Trans-port	(7) Trade	(8) Other services
	Panel A: Women							
Treated commune (0/1)	0.020	0.106	0.003	-0.012	-0.015	-0.003	-0.043	0.039
	[0.027]	[0.034]	[0.014]	[0.016]	[0.009]	[0.001]	[0.030]	[0.026]
RI p-value (t)	0.552	0.079	0.886	0.695	0.613	0.046	0.398	0.360
Never-treated mean, 2002	0.327	0.661	0.026	0.036	0.002	0.001	0.214	0.047
Observations	268	266	266	266	266	266	266	266
Treated communes	5	5	5	5	5	5	5	5
Total communes	268	268	268	268	268	268	268	268
	Panel B: Men							
Treated commune (0/1)	0.014	0.007	-0.026	0.003	0.001	0.004	0.025	-0.013
	[0.021]	[0.024]	[0.021]	[0.007]	[0.004]	[0.008]	[0.014]	[0.012]
RI p-value (t)	0.594	0.843	0.345	0.788	0.857	0.768	0.249	0.486
Never-treated mean, 2002	0.880	0.565	0.099	0.058	0.040	0.038	0.116	0.084
Observations	268	268	268	268	268	268	268	268
Treated communes	5	5	5	5	5	5	5	5
Total communes	268	268	268	268	268	268	268	268

Notes: First differences 2002–2013, one observation per commune, ages 25–54, by sex; robust standard errors in brackets. Never-treated communes as in Tables 2–3. Treated: the commune contains a settlement 350 m–10 km from a commercial farm by 2013. Column (1): employed over population of the same sex. Columns (2)–(8): shares of classified employment, sectors by occupation (unclassifiable records excluded from the denominator; domestic work included, not shown). RI p-values from 1000 permutations of the treatment indicator (t-statistic). Weighted by 2002 commune population aged 25–54 of the same sex. Sample: the SRV cluster and the never-treated communes. Excluded: the SRV delta (Ronkh, Mbane, Gae), urban Dakar and Rufisque, communes inside another cluster's 10 km ring, the Petite Côte, Tattaguine and Touba Toul.

Appendix

A.1 Labor Intensities

Table A.1.1: Labor intensities by gender - 8 hour equivalent days per year and ha

Crop	Total	Male	Female	N (farms)
Panel A: Annual Crops				
Groundnut	133.87	51.58	82.29	2
Maize	155.60	9.23	146.36	3
Squash	215.10	103.60	111.49	4
Carrot	298.80	90.88	207.93	2
Melon	364.63	162.53	202.10	4
Watermelon	466.10	203.60	262.50	4
Radish	826.54	18.85	807.69	1
Pepper	1,017.52	84.29	933.23	3
Onion	1,033.59	189.34	844.25	8
Beans	1,299.37	48.78	1,250.60	7
Tomatoes	1,598.24	375.12	1,223.12	2
Green Onion	2,683.00	11.52	2,671.48	2
Average	841.03	112.44	728.59	42
Panel B: Perennial Crops				
Mango	64.86	48.99	15.87	2
Acacia	144.09	144.09	0.00	3
Papaya	284.10	185.13	98.97	2
Banana	524.90	451.07	73.83	1
Average	254.49	207.32	47.17	8

Notes: Labor intensities are measured as eight-hour-equivalent labor days per hectare per year and are based on information collected during the 2024 farm survey. Reported values represent the average labor intensity across all farms cultivating a given crop. The final column reports the number of surveyed farms that provided labor-intensity information for the respective crop. Because farms often cultivate multiple crops, the same farm may contribute observations to more than one crop category. Consequently, the number of observations reflects the availability of crop-specific labor information rather than the total number of farms producing that crop in the full commercial farm database.

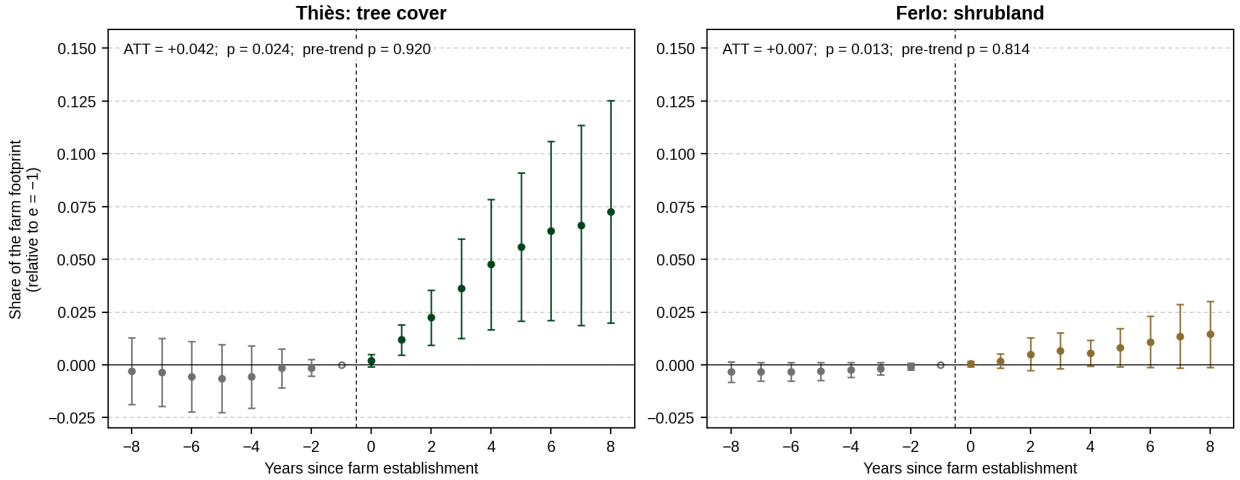
Table A.1.2: Permanent versus seasonal jobs by farm type

	Total		All other crops		Banana		Acacia	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Male workers during peak season (per ha)	1.42	0.64	1.20	0.65	1.73	0.40	2.02	0.20
Female workers during peak season (per ha)	2.36	2.15	3.17	1.90	1.31	2.22	0.00	0.00
Permanent male workers (per ha)	0.47	0.63	0.27	0.17	1.50	0.83	0.01	0.00
Permanent female workers (per ha)	0.12	0.16	0.12	0.19	0.21	0.05	0.00	0.00

Notes: The table reports means and standard deviations (SD) of the number of workers per hectare, separately by gender and for peak-season and permanent employment based on information collected during the 2024 farm survey. "Total" pools all farm groups. "Banana" and "Acacia" refer to the single-crop farms in the respective production clusters, while "All other crops" includes the remaining farms, covering both horticultural and staple-crop production. Workforce information was only available at the farm rather than the crop level. The reported figures therefore reflect each farm's overall production mix and should not be interpreted as crop-specific labor requirements

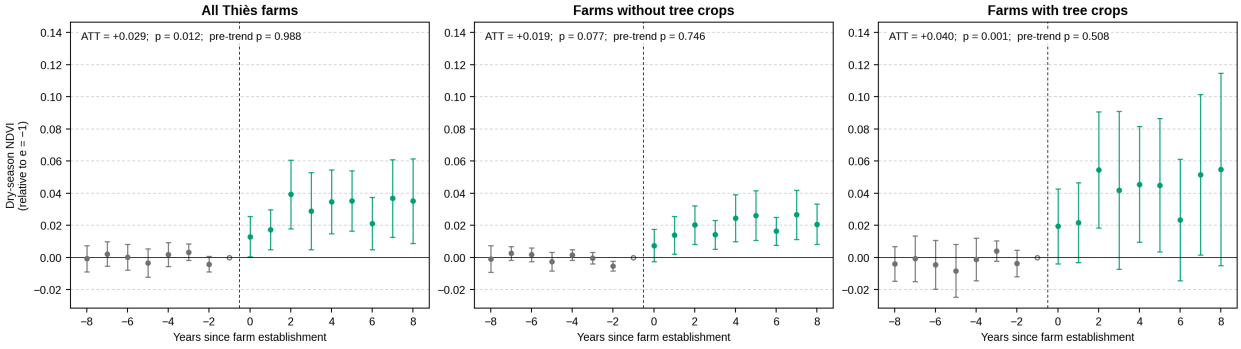
A.2 Additional Results on Land Use

Figure A.2.1: Land-use conversion in the Thiès and Ferlo clusters



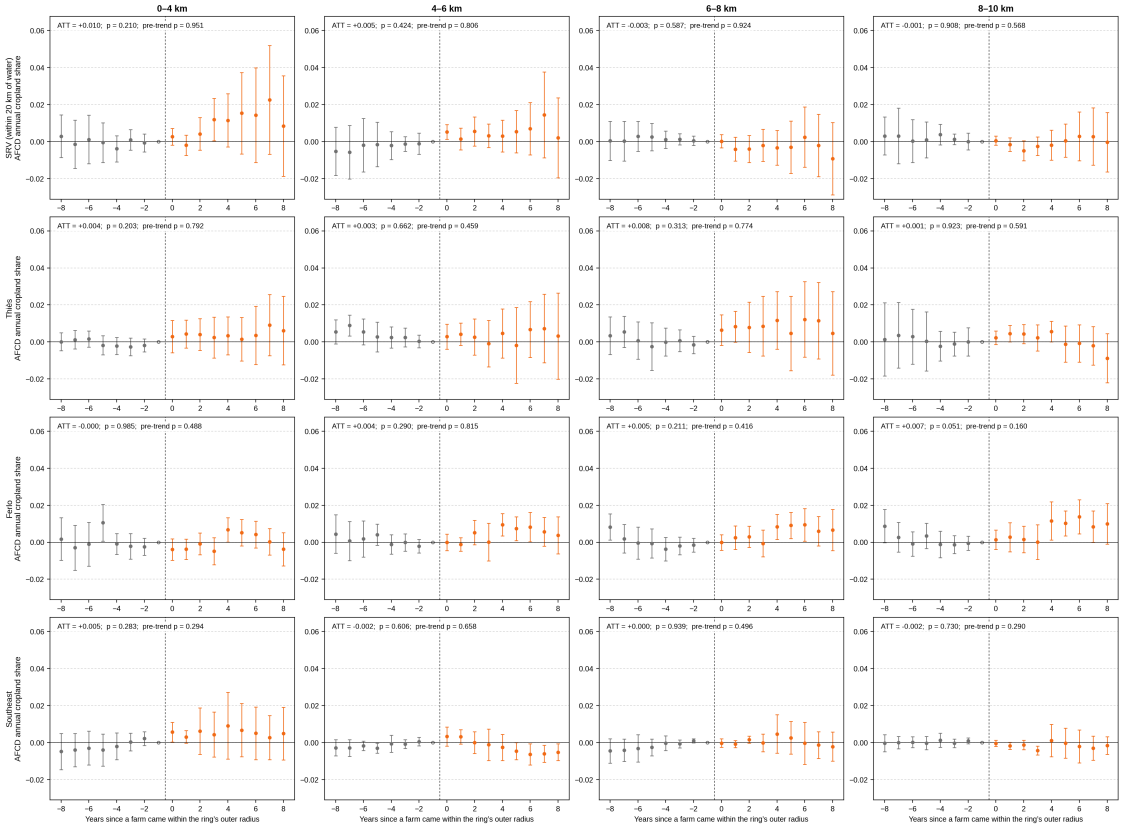
Notes: Outcomes: GLC_FCS30D forest (tree cover) share in Thiès (left) and shrubland share in the Ferlo (right); estimation, inference, units, data period, restrictions, treatment and controls as in Figure 4. Observations: treated (control) cells: Thiès 261 (15,712), Ferlo 1,183 (43,713).

Figure A.2.2: Dry-season NDVI on the farm footprint in Thiès, by whether the farm grows tree crops



Notes: Outcome: dry-season NDVI on the Thiès farm footprint; estimation, inference, units, data, restrictions and controls as in Figure 4. Treatment: footprint cells of all farms (left), of the five farms that report annual crops only (middle) and of the six farms that report any tree crop (mango, papaya, banana, citrus or cashew; right), from our farm survey and crop inventory; one farm without a crop record enters the left panel only. Observations: 261, 121 and 132 treated cells; 15,665 control cells in every panel.

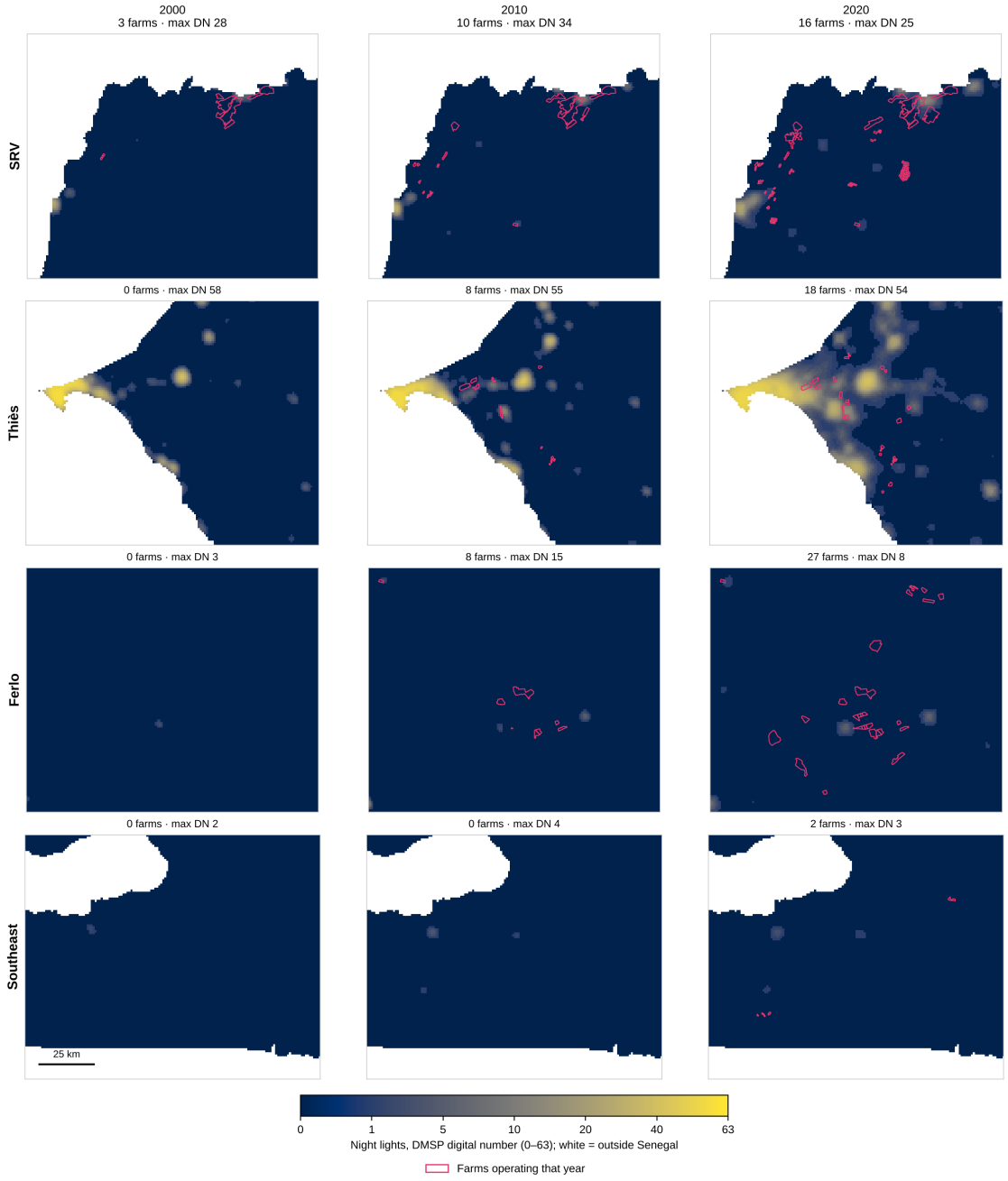
Figure A.2.3: Annual cropland around the farms: local control, disjoint rings



Notes: Outcome: AFCD annual cropland share; units are 500 m cells in four disjoint rings around the farms' maximum extent (350 m–4, 4–6, 6–8, 8–10 km). Data: AFCD, 2000–2022. Restrictions: as in Figure 4; in the SRV, treated and control cells are restricted to those within 20 km of a river or lake. Treatment: entry is the first year a farm comes within the ring's outer radius (2002–2022); controls are never-treated cells 15–40 km from any farm whose nearest farm is in the same cluster, the same in every panel of a row. Observations: treated cells by ring (0–4/4–6/6–8/8–10 km): SRV 4,432/2,539/2,615/2,564; Thiès 2,714/1,960/1,985/1,794; Ferlo 5,981/3,962/3,949/3,769; southeast 1,055/990/1,284/1,448; control cells: 9,902, 15,712, 43,713 and 33,112. Estimation and inference: as in Figure 4.

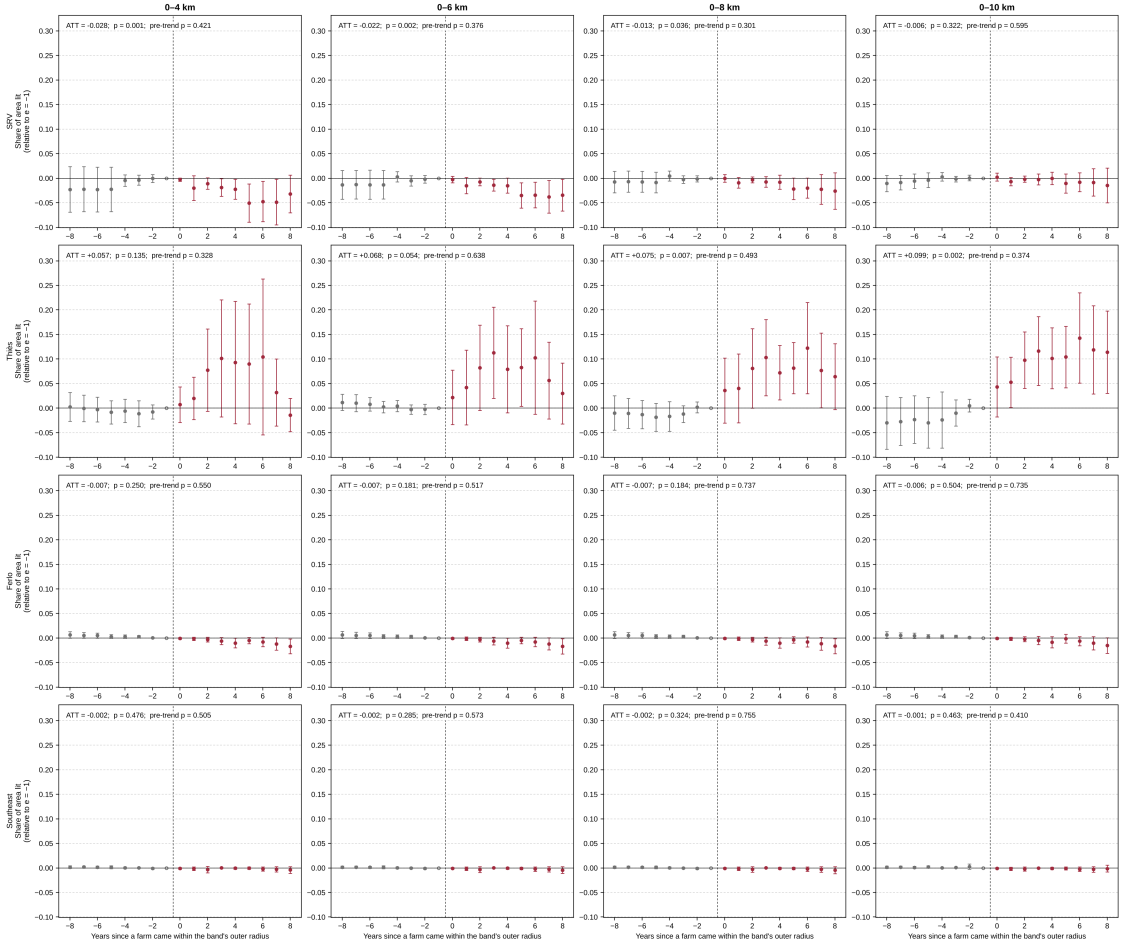
A.3 Additional Results on Nighttime Luminosity

Figure A.3.1: Nighttime light intensity over time



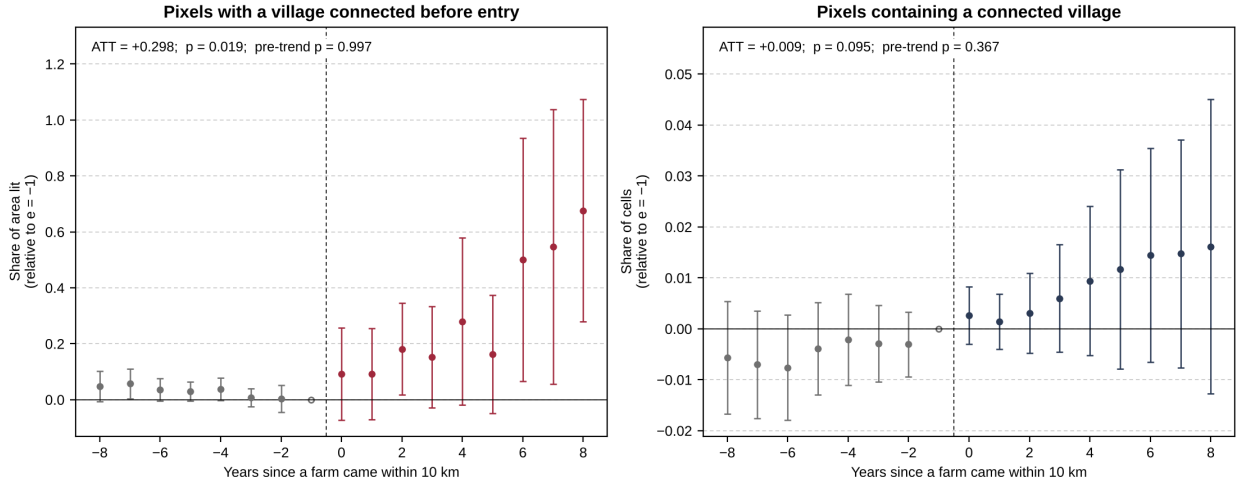
Notes: This figure shows nighttime light intensity (Chiovelli et al. 2026) measured in DMSP digital numbers (0–63) on the native 30 arc-second grid (approx. 1 km × 1 km).

Figure A.3.2: Change in the share of lit cells after farm entry: robustness to the treatment radius



Notes: Outcome, estimation, inference, units, data, restrictions and controls as in Figure 5. Treatment: cells within cumulative bands of 0–4, 0–6, 0–8 and 0–10 km of a farm's maximum extent (columns), entry the first year a farm comes within the band's outer radius; the 0–10 km column reproduces Figure 5. Observations: treated cells by band (0–4/0–6/0–8/0–10 km): SRV 2,990/5,039/7,163/9,264; Thiès 457/1,011/1,745/2,727; Ferlo 3,455/6,208/9,612/13,696; southeast 717/1,505/2,557/3,894; control cells as in Figure 5. All panels share a common y-axis scale.

Figure A.3.3: Night lights and village grid connections in Thiès

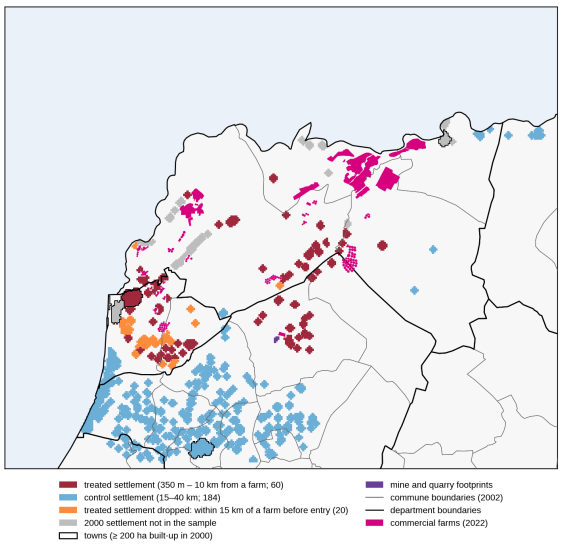


Notes: Outcomes: share of area lit (left) and share of cells whose 1 km night-light pixel contains a grid-connected locality (right); units are the Thiès 500 m cells of Figure 5. Data: night lights as in Figure 5, linked to the government register of localities and the year each was connected to the grid; a pixel counts as connected from the earliest commissioning year of a locality inside it, and localities without a date are not counted. Restrictions: as in Figure 5, cohorts entering by 2018, years 2000–2018 (left) and 1994–2018 (right). Treatment and control: left, each cohort's treated cells whose pixel was connected in the year before entry against control cells connected by the same year; right, as in Figure 5. Observations: left, 48 treated cells near 6 farms; right, 2,449 treated cells near 9 farms and 13,398 control cells in 31 communes. Estimation and inference: as in Figure 4.

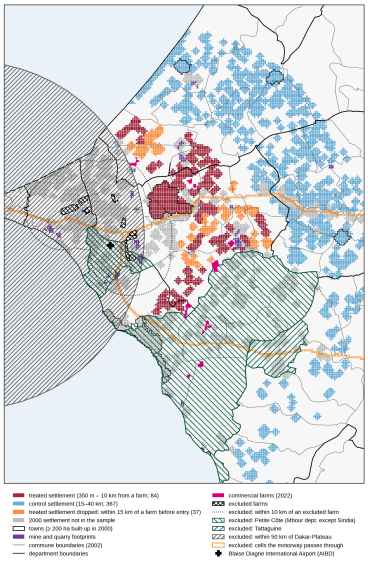
A.4 SRV and Thiès: Sample Definition

Figure A.4.1: Settlements present in 2000: treated and control groups

(a) SRV



(b) Thiès

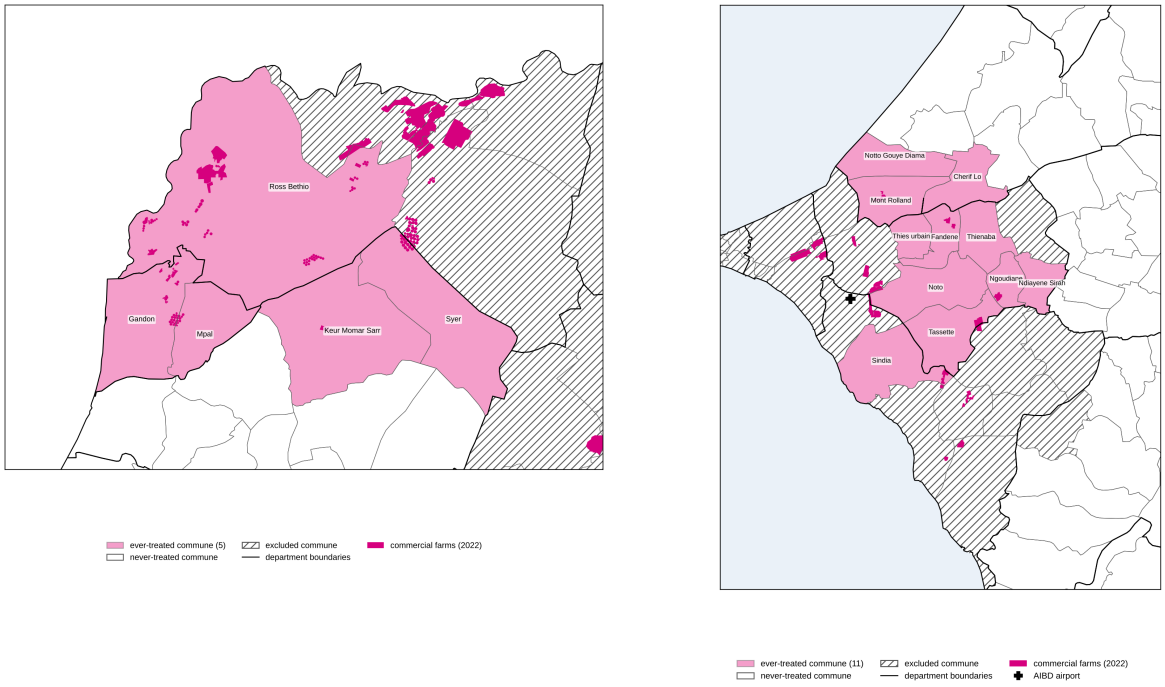


Notes: The maps show the settlement sample for the SRV (panel a) and Thiès (panel b). A settlement is an 8-connected cluster of 500 m cells with at least 5% built-up cover in 2000 (GLC_FCS30D). Treated settlements (red) lie 350 m to 10 km from a commercial farm of the cluster and first come within 10 km of a farm between 2002 and 2022; settlements already within 10 km of a farm by 2001 are not in the sample. Treated settlements that were already within 15 km of a farm in the year before entry are dropped (orange); farms located in 2002 communes that already contained a farm in 1999–2001 do not count for this rule. Control settlements (blue) lie 15–40 km from the nearest farm, which belongs to the same cluster. Grey settlements lie within these distance bands but are excluded by one of the rules below. Magenta: commercial farms in 2022; thick lines: department borders; thin lines: 2002 commune borders. Towns (at least 200 ha built up in 2000; black outline) are kept, but a town is treated only if at least half of its built-up cells lie within 10 km of a farm in its entry year (this excludes Saint-Louis), and the cells of a town hit by the motorway, mine or excluded-farm rules are removed from its zone instead of the town being dropped. Excluded in both clusters: settlements touching a mine or quarry footprint (purple) and settlements touching a 500 m cell that a motorway passes through (orange outline; OpenStreetMap). In Thiès, also excluded: settlements with any cell within 50 km of Dakar-Plateau (grey hatching), in Diender Guedji and Keur Moussa, within 10 km of an excluded farm (excluded farms cross-hatched, their 10 km radius dotted), in the Petite Côte (the 2002 Mbour department except Sindia) or in Tattaguine (green hatching). The cross marks Blaise Diagne International Airport. Treated settlements: SRV 60 (9 farms), Thiès 84 (9 farms); control settlements: SRV 184, Thiès 367.

Figure A.4.2: Ever-treated and never-treated communes in the census samples

(a) SRV

(b) Thiès



Notes: The maps show the 2002 communes used in the census analysis for the SRV (panel a) and Thiès (panel b). Ever-treated communes (pink) contain a treated settlement of Figure A.4.1, i.e. a settlement located 350 m to 10 km from a commercial farm of the cluster; all of them are treated by 2013 (SRV: 5 communes; Thiès: 11 communes). Never-treated communes (white) form the control group. Hatched communes are excluded from the sample. In the SRV, these are the communes of the delta (Gae, Mbane and Ronkh) and communes within 10 km of a farm of another cluster. In Thiès, these are the departments of the Dakar region, communes whose centroid lies within 50 km of Dakar-Plateau (except Sindia), Diender Guedji and Keur Moussa, the Petite Côte (including the urban communes of Mbour), and Diass, Malécounda, Guéniène, Sandiara, Diagagnao, Fissel, Sessene, Tattaguine and Touba Toul. Magenta: commercial farms in 2022; thick lines: department borders; thin lines: 2002 commune borders. The cross in panel (b) marks Blaise Diagne International Airport.

A.5 Spatial Event Studies: Robustness

Table A.5.1: Robustness of the spatial event studies, SRV and Thiès

	Farm footprint				Night lights, 0–10 km		Settlements, 0–10 km	
	Annual cropland		Dry-season NDVI		Share of area lit		Built-up share	
	(1) SRV	(2) Thiès	(3) SRV	(4) Thiès	(5) SRV	(6) Thiès	(7) SRV	(8) Thiès
Baseline	0.154	-0.017	0.033	0.029	-0.006	0.099	0.0005	0.0025
	(0.001)	(0.022)	(0.002)	(0.012)	(0.322)	(0.002)	(0.350)	(0.111)
Farms	12	12	12	12	13	9	9	9
Treated units	816	261	816	261	9,264	2,727	60	84
Control group 15–50 km	0.154	-0.018	0.033	0.029	-0.011	0.097	0.0007	0.0026
	(0.001)	(0.018)	(0.005)	(0.013)	(0.084)	(0.002)	(0.173)	(0.161)
Farms	12	12	12	12	13	9	9	9
Treated units	816	261	816	261	9,264	2,727	60	84
Control group 15–60 km	0.153	-0.017	0.032	0.029	-0.010	0.102	0.0008	0.0027
	(0.001)	(0.032)	(0.002)	(0.003)	(0.133)	(0.001)	(0.138)	(0.141)
Farms	12	12	12	12	13	9	9	9
Treated units	816	261	816	261	9,264	2,727	60	84
Drop within 5 km of a mine					-0.003	0.074	0.0005	0.0021
					(0.564)	(0.003)	(0.353)	(0.427)
Farms					13	9	9	9
Treated units					8,850	1,664	58	42
Thiès: 2000–2015 only (before						0.085		0.0036
the airport)						(0.006)		(0.094)
Farms						9		9
Treated units						2,449		78
Thiès: Mbour communes						0.062		0.0016
added back, as treated						(0.008)		(0.090)
Farms						10		10
Treated units						4,700		123
Thiès: excluding Thiès town						0.105		0.0018
						(0.003)		(0.098)
Farms						9		9
Treated units						2,515		83

Notes: Each cell reports the average treatment effect on the treated over event times $e = 0, \ldots, 8$ (Callaway and Sant'Anna 2021, never-treated controls, no covariates, relative to $e = -1$), the randomization-inference p-value on its t-statistic in parentheses (MacKinnon and Webb 2020, 999 draws), the number of farms and the number of treated units. Units are 500 m cells (columns 1–6) and settlements present in 2000 (columns 7–8). Columns (1)–(4): farm footprint (cells within 350 m of a farm), AFCD annual cropland share and dry-season NDVI (Figure 4). Columns (5)–(6): share of area lit, cells 350 m to 10 km from a farm (Figure 5). Columns (7)–(8): built-up share of the settlement zone (Figure 6). Baseline: as in Figures 4–6, never-treated controls 15–40 km from the nearest farm of the same cluster. Control group 15–50 km and 15–60 km: controls 15–50 or 15–60 km from the farms. Drop within 5 km of a mine: every treated and control cell, or every settlement with a zone cell, within 5 km of a mine is dropped, instead of only mine footprints. Thiès: 2000–2015 only: panel ends in 2015 and cohorts entering after 2015 are dropped. Thiès: Mbour communes added back, as treated: treated units in the Petite Côte (the 2002 Mbour department except Sindia) are kept; Petite Côte controls remain excluded. Thiès: excluding Thiès town: cells in the commune of Thiès urbain (night lights) and the Thiès town settlement (built-up) are dropped. Empty cells: specification not estimated for that outcome or cluster.

A.6 Harmonising Commune Definitions across the Censuses

Senegal's communes are not stable units over our study period. Decentralisation reforms created new urban communes (in 1996, 2002 and 2008), split rural communities into several communes and renamed many units. Each census wave identifies households by the units, names and codes in force at the time of enumeration. To follow the same places over time, we map all three waves onto the 2002 boundaries. These are the coarsest of the three, and later communes mostly arise from splits of 2002 units, so aggregating 2013 and 2023 communes to their 2002 parent preserves comparability without having to divide observations across areas.

No shapefile containing commune boundaries exists for the 2002 census communes. We reconstruct them from 2007 administrative maps and two commune boundary shapefiles: one reflecting the administrative division of the late 2000s, and the 2023 ANSD shapefile of the communes in the 2023 census. First, we match each 2023 and late 2000s commune to the 2002 commune boundaries. This is done manually for the late 2000s boundaries and computed with an overlay and checked for the 2023 boundaries. Second, we match the commune names of each census wave to the corresponding 2002 commune boundaries. Figure A.8.1 maps the resulting 2002 communes, shaded by their population density at baseline.

A.7 Harmonising Sector of Employment across the Censuses

A.7.1 The problem

The census rounds do not ask about work in the same way, and the differences are not cosmetic. The 2002 questionnaire has no question on the branch of activity: a respondent's economic sector can only be inferred from the occupation recorded in the QB18 list. The 2013 round introduced a branch question coded to ISIC Rev. 4, alongside an ISCO-08 occupation code, a coarse activity list and a free-text description. The 2023 round retained a branch question, coded instead to the regional NAEMA nomenclature, and also carries an ISCO-08 occupation code and a coarse activity list.

For our main comparison between 2002 and 2013, the key issue is therefore that occupation is the only substantive work classification observed in both waves. Using branch of activity in 2013 would compare an occupation-based classification in 2002 with an establishment-sector classification in 2013 and could generate apparent changes that partly reflect the change in measurement instrument. We therefore use an occupation-based harmonisation for the 2002–2013 analysis. We use the additional information available in 2013 to assess

and improve classification where the occupation field is uninformative, and use the branch variable as a validation check rather than as the primary classifier.

Table A.7.1 sets out what each round offers and how much of it is usable.

Table A.7.1: Work-related instruments by census round

	2002 (RGPH-3)	2013 (RGPHAE)	2023 (RGPH-5)
Branch of activity	not asked	ISIC Rev. 4 (B39)	NAEMA (B39A)
Occupation code	QB18 list	ISCO-08 (B40)	ISCO-08 (B40)
Coarse activity list	—	B37	B37
Free-text description	—	yes	yes

Notes: The 2002 census records occupation but not branch of activity. Our 2002–2013 harmonisation therefore uses occupation as the common basis for classifying employment sectors. The additional 2013 fields are used where the occupation information is uninformative and for validation. We do not use 2023 for the employment-composition analysis; see Section A.7.6.

A.7.2 Preferred occupation-based harmonisation

Our preferred classification uses occupation as the primary source of sector information in both 2002 and 2013. This keeps the basis of classification as similar as possible across the two waves. We map occupations into the seven broad categories used in the paper: crop agriculture; other primary activities; manufacturing; construction; transport; trade; and other services.

The 2002 round is classified directly from the QB18 occupation list. The occupation code is either mapped into one of our broad sectors or, if it contains no usable occupational information, left unclassified.

In 2013, we begin with the ISCO-08 occupation code. Most codes map directly into the same broad sector categories. Where the occupation code is missing or is one of the CAPI default codes 9990–9996, we use the free-text descriptions of occupation and activity. We first apply keyword rules covering common French and Wolof renderings and then a manually coded table of residual text combinations. If the text is also uninformative, we use the coarse B37 activity list as a final fallback. The branch-of-activity variable is not used to assign the main 2002–2013 sector outcomes.

For trade, we use a relatively inclusive rule because selling activities appear under several occupational descriptions. A worker is classified as being in trade if the usable occupation information, or the auxiliary text or activity information used when occupation is uninformative, clearly indicates sales or trading.

A.7.3 Unclassified employment

Records for which the available information yields no sector are removed from the denominator rather than pooled into a residual category. This is a consequential choice and we make it explicitly. A record with no usable occupation code and no informative auxiliary description is one for which the census has recorded too little information to assign a sector. Treating such records as a substantive residual sector would make changes in enumeration quality appear as changes in employment composition.

This mattered in earlier versions of the analysis. A residual category that retained otherwise unclassifiable records produced a large positive coefficient in one treated cluster, which disappeared once records without substantive employment information were removed. All sector shares reported in the paper are therefore shares of classified employment.

A.7.4 Validation using the 2013 branch variable

The 2013 census allows us to assess the occupation-based mapping because, for a subset of respondents, both occupation and a usable branch of activity are observed. Branch is conceptually closer to sector because it records the activity of the establishment, whereas occupation records what the individual does. We therefore use the branch classification as a validation benchmark in 2013, but not as the main harmonisation rule, since no comparable branch variable exists in 2002.

On the subset of 2013 records with a usable branch code, the occupation-based rule recovers crop agriculture with recall 0.83 and precision 0.97, livestock with 0.82 and 0.75, trade with 0.78 and 0.76, and transport with 0.88 and 0.74. Mining is essentially not identified from occupation alone, with recall 0.01, which is one reason we pool mining with other primary activities throughout. These comparisons should be read as an upper bound on classification performance because respondents with a complete work module are likely to be better enumerated than average.

A.7.5 Problems with the 2023 occupation field

The 2023 census formally also records occupation using ISCO-08, which might suggest that the same occupation-based harmonisation could simply be extended to that wave. In practice, however, the occupation field contains several high-frequency codes that do not appear to represent occupations.

Four codes together account for 44.0 per cent of the weight in B40. Code 2655, nominally actors (*Acteurs*), carries 10.2 per cent of the weight. It appears on no 2013 record under the

same ISCO-08 numbering, and its free-text descriptions include COMMERCE, MACON and TAILLEUR. Code 3323, nominally buyers (*Acheteurs*), carries 9.4 per cent, is likewise absent from 2013, and is blank in the free text for 88 per cent of its records. Codes 9999 and 9987, carrying 10.5 and 13.9 per cent, are explicit non-codable values rather than occupations.

For diagnostic purposes, we treat these four codes as missing and examine whether the remaining text and activity fields can recover a plausible sector classification. Other common codes survive the same checks. Drivers, bricklayers, domestic cleaners, subsistence farmers and tailors, for example, have free-text descriptions that closely match their occupational codes.

A.7.6 Why the 2023 round is not used for the composition of employment

We therefore do not use the 2023 census to study the sectoral composition of employment.

The problem is visible in the final classification rates. Records for which no usable information yields a sector are 1.4 per cent of employed men in 2002 and 1.2 per cent in 2013, compared with 9.5 per cent in 2023. For women, the corresponding shares are 12.2, 12.9 and 24.1 per cent. Classification completeness is therefore very similar in 2002 and 2013 but deteriorates sharply in 2023.

The key concern is not simply that 2023 uses a different coding system. Formally, its occupation variable is again labelled ISCO-08. Rather, the occupation field itself contains a very large share of codes that are not credible occupational classifications, and the auxiliary fields available to recover those records are not fully comparable with 2013. Extending the employment-composition analysis to 2023 would therefore introduce a substantial measurement break precisely in the outcomes we want to compare over time.

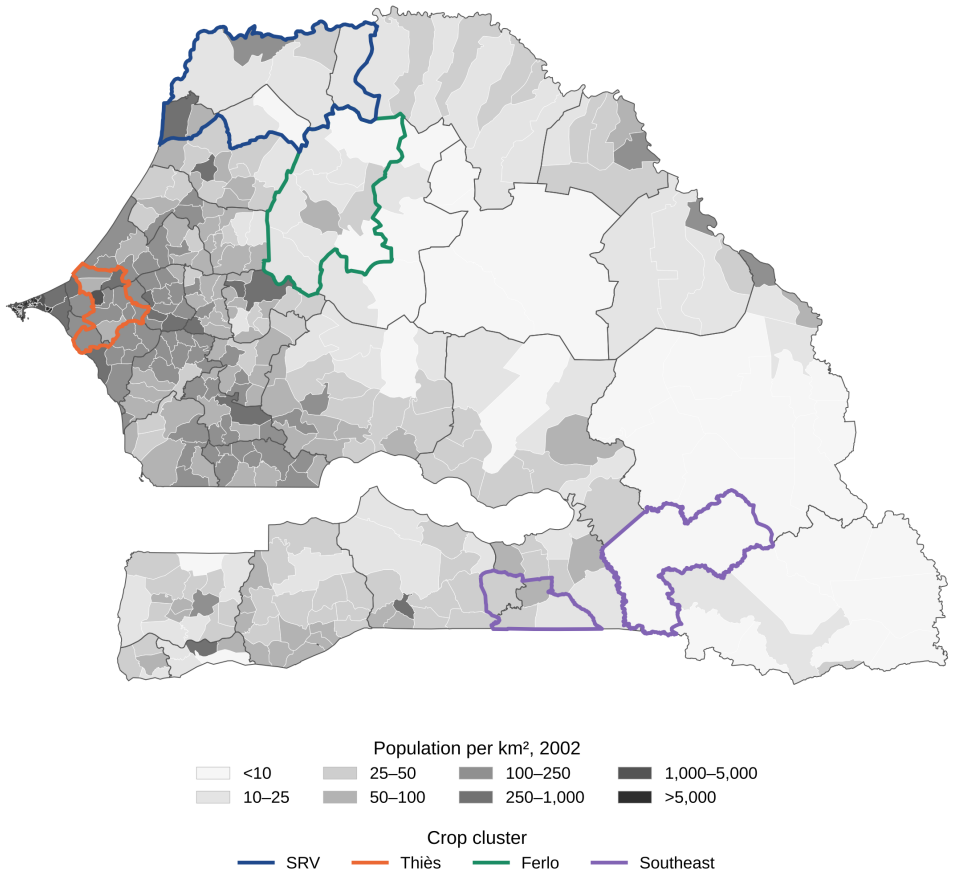
We consequently restrict the employment-composition analysis to 2002 and 2013, where occupation provides a common basis of classification and the share of unclassified employment is very similar across waves.

A.7.7 Remaining limitations

Three limitations remain. First, the census records a main activity over the preceding twelve months, so seasonal wage work on commercial farms may be under-recorded regardless of the classification rule. Second, the 2002 occupation list is coarser than ISCO-08 and several of its codes are catch-all categories, which limits how finely sectors can be distinguished. Third, the manual coding of residual free text in 2013 was carried out by the authors with knowledge of the project's hypotheses. We therefore report the coding rules and manually classified residuals in the replication package so that these assignments can be inspected.

A.8 Additional Census Results

Figure A.8.1: Population density by commune, 2002



Notes: Population per km^2 in each 2002 commune, computed from the 2002 census (10% sample, multiplied by 10) and the area of the reconstructed 2002 commune boundaries. Grey lines: department borders. Coloured outlines delimit the communes of each crop cluster; the Thiès outline covers its 11 ever-treated communes (Figure A.4.2b).

Table A.8.1: Thiès, 2002–2013: selected non-farm activities

	(1) Food processing, restaurants	(2) Hairdressing, beauty	(3) Tailoring, garments	(4) Education, health	(5) Joinery, metal, vehicle repair
	Panel A: Women				
Treated commune (0/1)	0.008	0.016	0.016	0.023	-0.000
	[0.008]	[0.006]	[0.011]	[0.007]	[0.001]
RI p-value (t)	0.549	0.106	0.275	0.023	0.977
Never-treated mean, 2002	0.015	0.007	0.017	0.021	0.002
Observations	272	272	272	272	272
Treated communes	11	11	11	11	11
Total communes	274	274	274	274	274
	Panel B: Men				
Treated commune (0/1)	0.001	0.001	0.001	-0.012	0.007
	[0.002]	[0.001]	[0.004]	[0.005]	[0.008]
RI p-value (t)	0.836	0.293	0.815	0.096	0.544
Never-treated mean, 2002	0.010	0.000	0.017	0.038	0.030
Observations	274	274	274	274	274
Treated communes	11	11	11	11	11
Total communes	274	274	274	274	274

Notes: First differences 2002–2013, one observation per commune, ages 25–54, by sex; robust standard errors in brackets. Never-treated communes as in Tables 2–3. Treated: the commune contains a settlement 350 m–10 km from a commercial farm by 2013. Shares of classified employment in selected non-farm activities, by occupation; not a partition. Column (1) includes restaurants and food stalls; column (5) joinery, metal work and vehicle repair. RI p-values from 1000 permutations of the treatment indicator (t-statistic). Weighted by 2002 commune population aged 25–54 of the same sex. Sample: the Thiès cluster and the never-treated communes. Thiès treated communes: Cherif Lo, Fandene, Mont Rolland, Ndiayene Sirah, Ngoudiane, Noto, Notto Gouye Diama, Sindia, Tassette, Thienaba, Thiès urbain. Excluded throughout: the Petite Côte (Mbour department except Sindia), Tattaguine, Touba Toul, Thiès-cluster communes within 50 km of the Dakar Plateau (except Sindia), urban Dakar and Rufisque, the SRV delta (Ronkh, Mbane, Gae), and communes inside another cluster's 10 km ring.

Table A.8.2: Equality of effects in the SRV and Thiès

	(1) SRV	(2) Thiès	(3) Difference (2) − (1)	(4) SE of difference	(5) RI p-value, equality
Panel A: Population (Table 2)					
Log population, first census after entry	0.063	0.028	-0.035	0.091	0.745
Log population, 2023	0.259	0.193	-0.066	0.108	0.599
Log in-migrants, first census after entry	-0.222	0.178	0.400	0.219	0.130
Log in-migrants, 2023	0.543	0.795	0.251	0.335	0.506
Panel B: Household wealth (Table 3)					
Wealth index, first census after entry	0.170	0.352	0.183	0.062	0.017
Wealth index, 2023	0.011	0.432	0.421	0.137	0.089
Panel C: Women's employment, 2002–2013 (Tables 4–5)					
Crop agriculture	0.106	0.089	-0.017	0.040	0.756
Manufacturing	-0.012	0.018	0.030	0.018	0.269
Other services	0.039	0.035	-0.004	0.027	0.908
Panel D: Men's employment, 2002–2013 (Tables 4–5)					
Crop agriculture	0.007	-0.015	-0.022	0.024	0.375
Manufacturing	0.003	0.008	0.006	0.007	0.476
Transport	0.004	0.023	0.019	0.011	0.249
Trade	0.025	-0.001	-0.026	0.013	0.201

Notes: Columns (1)–(2): SRV and Thiès estimates with the samples, weights and horizons of their source tables (Panels A–B: $ATT(2013, 2013)$ and $ATT(2013, 2023)$; Panels C–D: 2002–2013 first differences). Panel A unweighted; Panels B–D weighted by 2002 commune population aged 25–54 (same sex in C–D). Column (4): standard error of the difference from commune-level influence functions; never-treated communes enter both estimates, so their two terms are netted. Column (5): exact RI p-value for equal effects, over all 4368 ways of labelling 5 of the 16 treated communes SRV, never-treated fixed; statistic $|(3)/(4)|$. Employment rows: the sectors discussed in the text.

A.8.1 First-differences with continuous treatment: employment outcomes

Table A.8.3: Thiès, 2002–2013: shares of classified employment, continuous treatment

	(1) Working (/pop.)	(2) Crop agri.	(3) Other primary	(4) Manu-facturing	(5) Constr-uction	(6) Trans-port	(7) Trade	(8) Other services
				Panel A: Women				
Change in farm hectares within 10 km, 1,000 ha	-0.024	0.078	-0.012	0.040	-0.002	0.008	-0.071	0.052
	[0.038]	[0.092]	[0.007]	[0.014]	[0.002]	[0.009]	[0.100]	[0.027]
RI p-value (t)	0.666	0.582	0.173	0.090	0.589	0.682	0.654	0.263
Never-treated mean, 2002	0.327	0.661	0.026	0.036	0.002	0.001	0.214	0.047
Observations	274	272	272	272	272	272	272	272
Treated communes	11	11	11	11	11	11	11	11
Total communes	274	274	274	274	274	274	274	274
				Panel B: Men				
Change in farm hectares within 10 km, 1,000 ha	0.031	-0.040	-0.028	0.014	0.011	0.023	0.005	0.016
	[0.050]	[0.025]	[0.022]	[0.011]	[0.013]	[0.021]	[0.009]	[0.028]
RI p-value (t)	0.675	0.252	0.389	0.365	0.624	0.479	0.723	0.737
Never-treated mean, 2002	0.880	0.565	0.099	0.058	0.040	0.038	0.116	0.084
Observations	274	274	274	274	274	274	274	274
Treated communes	11	11	11	11	11	11	11	11
Total communes	274	274	274	274	274	274	274	274

Notes: First differences 2002–2013, one observation per commune, ages 25–54, by sex; robust standard errors in brackets. Never-treated communes as in Tables 2–3. Regressor: 2002–2013 change in farm hectares (thousands) whose 10 km buffer touches the commune; zero without a farm within 10 km. Treated-commune count as in the binary table. Column (1): employed over population of the same sex. Columns (2)–(8): shares of classified employment, sectors by occupation (unclassifiable records excluded from the denominator; domestic work included, not shown). RI p-values from 1000 permutations of the hectare changes (t-statistic). Weighted by 2002 commune population aged 25–54 of the same sex. Sample: the Thiès cluster and the never-treated communes. Thiès treated communes: Cherif Lo, Fandene, Mont Rolland, Ndiayene Sirah, Ngoudiane, Noto, Notto Gouye Diama, Sindia, Tassette, Thienaba, Thiès urbain. Excluded throughout: the Petite Côte (Mbour department except Sindia), Tattaguine, Touba Toul, Thiès-cluster communes within 50 km of the Dakar Plateau (except Sindia), urban Dakar and Rufisque, the SRV delta (Ronkh, Mbane, Gae), and communes inside another cluster's 10 km ring.

Table A.8.4: SRV, 2002–2013: shares of classified employment, continuous treatment

	(1) Working (/pop.)	(2) Crop agri.	(3) Other primary	(4) Manu-facturing	(5) Constr-uction	(6) Trans-port	(7) Trade	(8) Other services
				Panel A: Women				
Change in farm hectares within 10 km, 1,000 ha	-0.004	0.039	0.001	-0.016	-0.012	-0.001	0.005	0.016
	[0.006]	[0.019]	[0.001]	[0.004]	[0.001]	[0.001]	[0.012]	[0.005]
RI p-value (t)	0.837	0.448	0.438	0.176	0.028	0.221	0.874	0.313
Never-treated mean, 2002	0.327	0.661	0.026	0.036	0.002	0.001	0.214	0.047
Observations	268	266	266	266	266	266	266	266
Treated communes	5	5	5	5	5	5	5	5
Total communes	268	268	268	268	268	268	268	268
				Panel B: Men				
Change in farm hectares within 10 km, 1,000 ha	0.012	0.012	-0.017	0.000	0.002	0.003	-0.001	-0.000
	[0.004]	[0.007]	[0.003]	[0.002]	[0.001]	[0.002]	[0.008]	[0.005]
RI p-value (t)	0.337	0.479	0.150	0.928	0.502	0.491	0.975	0.995
Never-treated mean, 2002	0.880	0.565	0.099	0.058	0.040	0.038	0.116	0.084
Observations	268	268	268	268	268	268	268	268
Treated communes	5	5	5	5	5	5	5	5
Total communes	268	268	268	268	268	268	268	268

Notes: First differences 2002–2013, one observation per commune, ages 25–54, by sex; robust standard errors in brackets. Never-treated communes as in Tables 2–3. Regressor: 2002–2013 change in farm hectares (thousands) whose 10 km buffer touches the commune; zero without a farm within 10 km. Treated-commune count as in the binary table. Column (1): employed over population of the same sex. Columns (2)–(8): shares of classified employment, sectors by occupation (unclassifiable records excluded from the denominator; domestic work included, not shown). RI p-values from 1000 permutations of the hectare changes (t-statistic). Weighted by 2002 commune population aged 25–54 of the same sex. Sample: the SRV cluster and the never-treated communes. Excluded: the SRV delta (Ronkh, Mbane, Gae), urban Dakar and Rufisque, communes inside another cluster's 10 km ring, the Petite Côte, Tattaguine and Touba Toul.

A.8.2 Alternative weighting

The tables in this section change the weighting of the main census tables. Tables A.8.5–A.8.7 repeat Tables 3, 4 and 5 without population weights, so that each commune carries the same weight. Table A.8.8 does the reverse for Table 2, which is unweighted in the main text: it weights each commune by its 2002 population aged 25–54, the weight of Table 3. Samples, treatment definitions and randomization inference are as in the main tables.

With population weights, the treated side of Table A.8.8 is dominated by the two largest treated communes. Gandon, on the edge of Saint-Louis, carries 70 per cent of the SRV treated weight, and Thiès urbain 49 per cent of the Thiès treated weight; no never-treated commune carries more than 8 per cent. The weighted estimates therefore mostly reflect population growth in these two communes, while Table 2 reports the change in the typical treated commune.

Table A.8.5: Household wealth and housing quality, 2002–2023 dynamic effects: unweighted

	Wealth index		Electric lighting		Flush toilet		Television		Car	
	(1) SRV	(2) Thiès	(3) SRV	(4) Thiès	(5) SRV	(6) Thiès	(7) SRV	(8) Thiès	(9) SRV	(10) Thiès
First census after entry	0.032	0.382	-0.009	0.161	0.081	0.149	0.018	0.162	0.010	0.029
	[0.089]	[0.077]	[0.034]	[0.053]	[0.056]	[0.030]	[0.051]	[0.041]	[0.008]	[0.010]
RI p-value (t)	0.786	0.001	0.853	0.021	0.293	0.003	0.770	0.008	0.326	0.010
Second census after entry (2023)	-0.084	0.711	-0.100	0.282	0.061	0.259	0.008	0.282	0.033	0.126
	[0.133]	[0.091]	[0.054]	[0.074]	[0.055]	[0.036]	[0.047]	[0.043]	[0.017]	[0.017]
RI p-value (t)	0.573	0.001	0.163	0.004	0.360	0.001	0.887	0.001	0.175	0.001
Never-treated mean, 2002	-0.589	-0.589	0.086	0.086	0.086	0.086	0.087	0.087	0.025	0.025
Observations	268	274	268	274	268	274	268	274	268	274
Treated communes	5	11	5	11	5	11	5	11	5	11
Total communes	268	274	268	274	268	274	268	274	268	274

Notes: Callaway and Sant'Anna (2021) estimates, never-treated controls, no covariates. Treated communes contain a settlement 350 m–10 km from a commercial farm (all treated by 2013). First row: $ATT(2013, 2013)$; second row: $ATT(2013, 2023)$. Thiès treated communes: Cherif Lo, Fandene, Mont Rolland, Ndiayene Sirah, Ngoudiane, Noto, Notto Gouye Diama, Sindia, Tassette, Thienaba, Thiès urbain. Excluded throughout: the Petite Côte (Mbour department except Sindia), Tattaguine, Touba Toul, Thiès-cluster communes within 50 km of the Dakar Plateau (except Sindia), urban Dakar and Rufisque, the SRV delta (Ronkh, Mbane, Gae), and communes inside another cluster's 10 km ring. Panel balanced on the three censuses. Standard errors clustered by commune in brackets; RI p-values from 1000 permutations of the cohort vector (t-statistic). Household means, each household weighted equally. Unweighted. Columns (1)–(2): wealth index, the first principal component of eighteen housing and asset indicators coded identically in the three censuses, loadings from never-treated households; in standard deviations of the 2002 distribution. Columns (3)–(10): shares of households with electric lighting, a flush toilet, a television, a car or truck.

Table A.8.6: Employment outcomes: Thiès, 2002–2013: unweighted

	(1) Working (/pop.)	(2) Crop agri.	(3) Other primary	(4) Manu-facturing	(5) Constr-uction	(6) Trans-port	(7) Trade	(8) Other services
	Panel A: Women							
Treated commune (0/1)	-0.013	0.079	-0.003	0.013	-0.002	0.007	-0.048	0.029
	[0.022]	[0.051]	[0.007]	[0.010]	[0.001]	[0.006]	[0.055]	[0.017]
RI p-value (t)	0.588	0.159	0.756	0.278	0.326	0.524	0.432	0.140
Never-treated mean, 2002	0.327	0.661	0.026	0.036	0.002	0.001	0.214	0.047
Observations	274	272	272	272	272	272	272	272
Treated communes	11	11	11	11	11	11	11	11
Total communes	274	274	274	274	274	274	274	274
	Panel B: Men							
Treated commune (0/1)	0.020	-0.025	-0.017	0.011	-0.001	0.027	-0.000	0.006
	[0.033]	[0.030]	[0.010]	[0.011]	[0.007]	[0.013]	[0.010]	[0.017]
RI p-value (t)	0.572	0.454	0.146	0.351	0.878	0.055	0.976	0.764
Never-treated mean, 2002	0.880	0.565	0.099	0.058	0.040	0.038	0.116	0.084
Observations	274	274	274	274	274	274	274	274
Treated communes	11	11	11	11	11	11	11	11
Total communes	274	274	274	274	274	274	274	274

Notes: First differences 2002–2013, one observation per commune, ages 25–54, by sex; robust standard errors in brackets. Never-treated communes as in Tables 2–3. Treated: the commune contains a settlement 350 m–10 km from a commercial farm by 2013. Column (1): employed over population of the same sex. Columns (2)–(8): shares of classified employment, sectors by occupation (unclassifiable records excluded from the denominator; domestic work included, not shown). RI p-values from 1000 permutations of the treatment indicator (t-statistic). Unweighted. Sample: the Thiès cluster and the never-treated communes. Thiès treated communes: Cherif Lo, Fandene, Mont Rolland, Ndiayene Sirah, Ngoudiane, Noto, Notto Gouye Diama, Sindia, Tassette, Thienaba, Thiès urbain. Excluded throughout: the Petite Côte (Mbour department except Sindia), Tattaguine, Touba Toul, Thiès-cluster communes within 50 km of the Dakar Plateau (except Sindia), urban Dakar and Rufisque, the SRV delta (Ronkh, Mbane, Gae), and communes inside another cluster's 10 km ring.

Table A.8.7: Employment outcomes: SRV, 2002–2013: unweighted

	(1) Working (/pop.)	(2) Crop agri.	(3) Other primary	(4) Manu-facturing	(5) Constr-uction	(6) Trans-port	(7) Trade	(8) Other services
	Panel A: Women							
Treated commune (0/1)	0.087	0.154	0.064	-0.009	-0.016	-0.002	-0.205	0.063
	[0.082]	[0.081]	[0.097]	[0.021]	[0.011]	[0.001]	[0.104]	[0.079]
RI p-value (t)	0.398	0.147	0.630	0.795	0.542	0.080	0.136	0.530
Never-treated mean, 2002	0.327	0.661	0.026	0.036	0.002	0.001	0.214	0.047
Observations	268	266	266	266	266	266	266	266
Treated communes	5	5	5	5	5	5	5	5
Total communes	268	268	268	268	268	268	268	268
	Panel B: Men							
Treated commune (0/1)	-0.025	0.033	-0.047	-0.019	-0.002	0.014	0.026	-0.004
	[0.065]	[0.033]	[0.027]	[0.014]	[0.006]	[0.014]	[0.017]	[0.020]
RI p-value (t)	0.719	0.409	0.161	0.319	0.772	0.429	0.234	0.862
Never-treated mean, 2002	0.880	0.565	0.099	0.058	0.040	0.038	0.116	0.084
Observations	268	268	268	268	268	268	268	268
Treated communes	5	5	5	5	5	5	5	5
Total communes	268	268	268	268	268	268	268	268

Notes: First differences 2002–2013, one observation per commune, ages 25–54, by sex; robust standard errors in brackets. Never-treated communes as in Tables 2–3. Treated: the commune contains a settlement 350 m–10 km from a commercial farm by 2013. Column (1): employed over population of the same sex. Columns (2)–(8): shares of classified employment, sectors by occupation (unclassifiable records excluded from the denominator; domestic work included, not shown). RI p-values from 1000 permutations of the treatment indicator (t-statistic). Unweighted. Sample: the SRV cluster and the never-treated communes. Excluded: the SRV delta (Ronkh, Mbane, Gae), urban Dakar and Rufisque, communes inside another cluster's 10 km ring, the Petite Côte, Tattaguine and Touba Toul.

Table A.8.8: Population and in-migrants, 2002–2023 dynamic effects: weighted by 2002 population

	Population		In-migrants	
	(1) SRV	(2) Thiès	(3) SRV	(4) Thiès
First census after entry	0.158	0.126	-0.100	0.222
	[0.062]	[0.080]	[0.107]	[0.130]
RI p-value (t)	0.069	0.236	0.552	0.192
Second census after entry (2023)	0.176	0.160	0.306	0.621
	[0.074]	[0.103]	[0.131]	[0.222]
RI p-value (t)	0.091	0.221	0.136	0.044
Never-treated mean, 2002	6.048	6.048	3.426	3.426
Observations	268	274	263	269
Treated communes	5	11	5	11
Total communes	268	274	268	274

Notes: Callaway and Sant'Anna (2021) estimates, never-treated controls, no covariates. Treated communes contain a settlement 350 m–10 km from a commercial farm (all treated by 2013). First row: $ATT(2013, 2013)$; second row: $ATT(2013, 2023)$. Thiès treated communes: Cherif Lo, Fandene, Mont Rolland, Ndiayene Sirah, Ngoudiane, Noto, Notto Gouye Diama, Sindia, Tassette, Thienaba, Thiès urbain. Excluded throughout: the Petite Côte (Mbour department except Sindia), Tattaguine, Touba Toul, Thiès-cluster communes within 50 km of the Dakar Plateau (except Sindia), urban Dakar and Rufisque, the SRV delta (Ronkh, Mbane, Gae), and communes inside another cluster's 10 km ring. Panel balanced on the three censuses. Standard errors clustered by commune in brackets; RI p-values from 1000 permutations of the cohort vector (t-statistic). Columns (1)–(2): log population aged 25–54; columns (3)–(4): log persons aged 25–54 born in another region of Senegal; both sexes. Weighted by 2002 commune population aged 25–54. Communes with no in-migrants in a census drop from columns (3)–(4).