Testing the Enclave Economy Hypothesis: A Dual-Sensor Satellite Study of the EACOP Corridor, Uganda

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Résumé

Ce mémoire examine l'hypothèse d'économie d'enclave le long du corridor Kingfisher–Tilenga / EACOP en Ouganda, à partir d'une géométrie vectorielle commune (eacopmap.org) et de deux chaînes géomatiques.

Sur Sentinel-2 (ArcGIS, février 2017 vs février 2025), les cartes montrent 147 km^2 de nouvelles surfaces en eau et 1 047 km^2 de perte de végétation sur 3 330 km^2 de terres persistantes, surtout au CPF, aux plateformes et le long des routes. Un panel NDVI GEE (2019–2025) sur pads et feeders, face aux mêmes contrôles ruraux, donne un DiD d'environ $-0{,}10$ après la FID 2022, avec des pré-tendances stables en 2019–2020.

Sur VIIRS VNP46A2 (2014–2025), un DiD sur 23 sites (9 enceinte, 6 régionaux, 8 contrôles, villages riverains sur les lacs Edward et Kyoga, retenus parmi 17 polygones candidats; Gulu et Masaka sont des villes secondaires hors du DiD rural) estime l'interaction enceinte × post-2022 à +0,245 (SE 0,113, $p \approx 0{,}04$), tandis que l'interaction régionale reste proche de zéro ($-0{,}026$). Dans ces séries, la perturbation physique se concentre sur les pads et feeders, tandis que la luminosité nocturne reste dans la bande d'enceinte de 15 km.

Les limites sont celles des proxys et de l'échantillon: la luminosité n'est pas le PIB, les cartes ArcGIS à deux dates ne sont pas un DiD, l'échantillon VIIRS ne compte que 23 clusters, et les produits ArcGIS sont en L1C. Le mémoire documente surtout un traitement ArcGIS Pro, des extraits GEE, et une lecture croisée des deux capteurs.

1 Introduction

The East African Crude Oil Pipeline (EACOP) is set to be the largest heated oil pipeline anywhere in the world. Upon completion, the system will link oil fields on the shores of Lake Albert in northern Uganda to the port of Dar es Salaam in Tanzania. Together with the upstream Kingfisher and Tilenga developments, the investment is valued at roughly $15 billion and has been framed as a source of employment, services, infrastructure, and regional growth. Yet the development economics literature suggests that those claims should not be taken as a given (Auty, 1993). Extractive projects can generate local demand and public investment; yet they can also form an extractive enclave that serves to benefit non-domestic capital (Michaels, 2011; Aragón and Rud, 2013).

Kingfisher sits on the eastern shore of Lake Albert in Kikuube District, western Uganda, and is operated by the China National Offshore Oil Corporation (CNOOC); Tilenga, further north, is operated by TotalEnergies, which is also the largest shareholder in the joint venture. The industrial footprint includes a central processing facility (CPF), well pads, feeder pipelines, an airstrip, haul roads, construction areas, and water-management features. This occupies a strip between the lake and higher ground called the Buhuka flats. The area sits directly on top of both wetlands and human settlements where people rely on both fishing and subsistence farming for their livelihood.

The project itself is highly controversial. Field reporting from Just Finance International records allegations of forced displacement, livelihood destruction, and severe human rights abuses by security personnel connected to the Kingfisher development, namely the Uganda People's Defence Force and its Fisheries Protection Unit (Just Finance International, 2025a,b). FIDH documents the same militarised pattern at the Kingfisher sites, including forced evictions, extortion, and gender-based violence, whilst Human Rights Watch records a wider crackdown on environmental defenders opposing the pipeline (International Federation for Human Rights et al., 2024; Human Rights Watch, 2023). In May 2025 the UN Special Rapporteur on environmental defenders, Michel Forst, called on TotalEnergies and its shareholders to take urgent action to protect communities and defenders around Tilenga, Kingfisher, and EACOP (Forst, 2025). TotalEnergies has consistently rejected these accounts as misconceptions. In its August 2025 reply to Forst the company went further, arguing that his mandate under the Aarhus Convention runs to states rather than private firms and that Uganda is not a party to the Convention, thereby seeking to place the allegations outside his authority (TotalEnergies, 2025). The project has also become an emblematic case for climate activists seeking to stop the expansion of fossil fuels, especially given that the IEA's net-zero pathway allows for no new oil and gas fields (Human Rights Watch, 2023; International Energy Agency, 2021).

Whilst oil was first discovered in the region in 2006, a Final Investment Decision (FID) for extraction was not made until February 2022. That date is the break used for the difference-in-differences where night lights are a proxy for local economic activity (Henderson et al., 2012). This allows a test of TotalEnergies' claims that the project would bring prosperity to the region in litigation before the French courts (Deutsche Welle, 2023; TotalEnergies, 2026).

Fundamentally this paper asks: Does the observable satellite footprint of the Kingfisher/EACOP construction phase remain concentrated near infrastructure, or does it extend into the surrounding regional settlement system?

This breaks into three sub-questions: what land and water changes are visible between the 2017 and 2025 Sentinel-2 scenes; whether greenness at pads and feeders declines after the 2022 FID relative to rural controls; and whether fenceline towns (within 15 km) and regional towns (15–40 km) experience different changes in VIIRS.

I use the industrial layer scraped from `eacopmap.org`, and towns and rural controls traced as settlement perimeters in Google Earth. Rural controls began as seventeen candidate polygons traced in Google Earth across three lakes; the main rural sample keeps eight small villages on Edward and Kyoga, holds Gulu and Masaka as secondary-city checks, and drops the Victoria-shore candidates because they sit too close to Kampala or to the pipeline corridor itself (Section 3). Road time to the Kingfisher Development Area then screens those eight. The principal tools used for this study were ArcGIS, Google Earth Engine (GEE), Python, and R. The VIIRS town panel has 23 sites (9 fenceline, 6 regional, and 8 rural controls) over 2014–2025.

The Sentinel-2 maps show about 147 km^2 of newly mapped open water, mostly Lake Albert shoreline rise, and, on 3,330 km^2 of persistent land, 1,047 km^2 of vegetation loss, with loss at the CPF, pads, and road corridors. The GEE NDVI DiD for 2019–2025 gives a post-2022 greenness of about -0.10 at pads and feeders. On VIIRS for 2014–2025 the fenceline result is $+0.245$, whilst the regional interaction remains close to zero at -0.026. Results from the 2014–2025 panel indicate that the change in night-lights stays within the 15 km fenceline. This provides some evidence of an enclave-style pattern rather than broad regional spillover.

The rest of this mémoire is divided into the following sections. Section 2 reviews the enclave literature. Section 3 describes the shared geometry and three empirical components. Section 4 presents the land-cover, NDVI, and radiance results before reading them together. Section 5 concludes.

2 Literature

2.1 Extractive development and enclave economies

The literature on the resource curse starts from a puzzle. Resource-rich countries often fail to convert mineral or petroleum wealth into development (Auty, 1993). Much of this may be due to a mechanism described by post-WWII development economist Hirschman (1958), whereby extraction fails to generate 'backward linkages' to local suppliers or 'forward linkages' to domestic industry. The economic surplus leaves the country without building up a surrounding production structure. Since modern mining and fossil fuel extraction requires specialised engineering, heavy equipment, and advanced technical services, domestic markets in developing countries rarely have the capital or industry to supply so this must be imported.

More recent theories emphasise that a large endowment can raise incomes whilst dependence on resource rents erodes institutional quality and, through it, development (Lashitew and Werker, 2020). In the United States, oil generated significant economic gains for oil-producing states (Michaels, 2011). Forward and backward linkages were established locally in mining and manufacturing. So integral were fossil fuels to US prosperity that they became fundamentally linked to the nation's cultural identity. Contrastingly, when institutions are weak, the rents from extraction tend to bypass local taxation and instead become captured by both international firms and government officials. In Angola a large mineral and fossil fuel endowment produced an enclave whose rent flows directly into global markets. These enclaves were ring-fenced from the rest of the country and heavily guarded. Production continued through the civil war but little to none of the rent reached the wider economy[1].

Phelps et al. (2015) argue that enclaves are produced through specific institutional choices. In their terms an enclave is a bounded territory specialised around one or a few large firms, with weak integration into the local economy. Localisation economies never form even when exports look strong. In their Chilean copper case, the old company town was replaced by a mining camp that exists only as a workplace. Labour and specialised suppliers are imported and organised from Santiago, so the host region keeps the mine whilst the linkages form in the capital. Further, Bury and Bebbington (2013, 44–45) describe how Andean states reorganised mining and hydrocarbons concessions and "developed infrastructure to provide access to remote areas where new hydrocarbons and mineral deposits were being discovered". The same reforms removed local hiring and sourcing requirements. Appel (2019, 24–25) found the same dynamic in Equatorial Guinea, whereby oil companies keep operations and housing inside the compound, cut off from life "outside their walls".

This arrangement limits how much spending reaches the host communities. In addition to internalising as much as possible, tenders for contracts that are put out to local businesses are often hard to secure. In the case of EACOP, operators enforce international technical and safety certifications, smallholders and fishing communities on the Buhuka flats cannot bid for catering, transport, or maintenance work. The Kingfisher camp runs on its own generators, has dedicated security lighting, and brings in food, fuel, and technical staff directly from Kampala by road or via the paved airstrip on the flats. Wages and procurement stay within the camp fence, so economic activity does not move into the wider 15–40 km settlement band.

What these cases share is a spatial pattern. The host region retains the extraction site but not the supply chain that feeds it. Kingfisher fits that description. Construction crews rotate through worker camps on the Buhuka flats. Specialised engineering, drilling, and logistics contracts run through Kampala-registered firms or international subcontractors rather than through local suppliers in Hoima or Kikuube. The lakeshore communities that formerly fished and farmed on the flats have been displaced or restricted rather than absorbed into the project workforce (Just Finance International, 2025a; International Federation for Human Rights et al., 2024). The heated pipeline will carry crude directly to the port of Dar es Salaam, 1,443 km to the southeast, bypassing the Albertine towns entirely. Appel (2019) describes this kind of arrangement as modularity. In this sense, facilities are designed to plug into global export logistics rather than into surrounding

[1]Ferguson describes this as a socially thin model of extraction in *Global Shadows: Africa in the Neoliberal World Order* (Ferguson, 2006, 201–203).

settlements.

A project can leave a large physical footprint, visible from orbit as cleared vegetation and compacted ground, without generating the backward linkages to local suppliers or forward linkages to domestic processing that Hirschman described. The spatial prediction from this literature is rather clear, if linkages form in the capital rather than the host district, post-construction activity should concentrate at the immediate fenceline (camp lighting, floodlights, security) and remain flat across the wider town network. Physical disturbance should track the industrial geometry without spreading across the plain. That two-part prediction is what the NDVI and VIIRS panels in Section 4 are designed to test.

The depth of local economic integration also can depend on state regulatory pressure and whether domestic suppliers can actually meet needs of the industry (Hansen, 2014). Following major oil discoveries across East Africa, regional governments introduced legislation to force purchases and employment toward domestic firms (Nwapi, 2016). As Nwapi (2016) points out, however, that East African petroleum regulations give preference to nationals as opposed to regional citizens.

Uganda's regulation attempts to implement this. The 2008 National Oil and Gas Policy, the 2013 Petroleum Acts, and the 2016 National Content Regulations mandate that Ugandan goods, services, and labour must be considered first (Sen, 2018, 2020). Under this regulation, a registered Ugandan company must employ at least 70 per cent Ugandans and register on the National Supplier Database. These requirements do not ask where the company is based. A contractor registered in Kampala that employs 70 per cent Ugandans satisfies this, meaning host-district firms in Kikuube or Hoima do not necessarily receive contracts. Beyond this legal gap, domestic supplier capability is a binding constraint.

An Industrial Baseline Survey commissioned by the operators found that as of 2013 only security services and cement manufacturing met the industry's quantity and quality requirements, leaving Ugandan firms unprepared for the most lucrative contracts the construction peak would bring (Sen, 2018, 2020). The survey assessed capability across many categories, these included drilling, engineering, procurement, construction, marine logistics camp management, and transport. In most of these it found no domestic supplier could meet the demands required by the operators. The result was that the construction peak drew on international contractors and Kampala-based joint ventures (often owned by foreign capital). Local businesses which lack the equipment, certifications, and technical workforce to compete are largely shut out of the supply chain.

This is not unique to Uganda. Tanzania's local content provisions for the EACOP pipeline segment follow the same logic (Barlow, 2020). A firm that is registered in Dar es Salaam satisfies the requirements regardless of whether it operates anywhere near the pipeline route. The regulatory design means that securing of business deals and tenders are channelled toward the capital city. What the host district receives is the physical footprint of construction traffic, cleared land, security deployment, and restricted lake access. The latter three act as human rights risk compounders for the communities on the ground.

2.2 Remote sensing for extractive footprints

Subnational economic statistics in rural Uganda are sparse and infrequently updated, so direct measurement of whether oil investment reaches host-district economies is difficult. Henderson et al. (2012) argue that satellite-measured luminosity provides a useful alternative. Their core finding is that national accounts in developing countries contain large measurement error, and that night-time lights, measured consistently from orbit, correlate with economic output at the subnational level. The relationship is not one-to-one and varies with economic structure, but it allows researchers to track relative changes in local activity where survey data is thin or absent. Michalopoulos and Papaioannou (2013) apply the same logic across ethnic homelands partitioned by colonial borders in sub-Saharan Africa, using luminosity differences to measure local development on either side of the boundary. The approach is well suited to the regional and site-level comparisons used in this mémoire, where treated settlement perimeters at different distances from infrastructure are compared against a set of rural controls.

Near extractive sites, night lights are an imperfect proxy for growth. VIIRS products such as NASA's Black Marble record gas flares, construction floodlights, and camp generators alongside ordinary town lighting (Román et al., 2018), so absolute radiance can rise with industrial operations even when local economies do not. That is a known limit of the luminosity approach in mining and oil settings, where the lights–output link is weaker than for services or retail (Gibson and Boe-Gibson, 2021). Optical imagery from Sentinel-2 complements this by tracking vegetation clearance at 10 m, which is useful where ground access is restricted (Drusch et al., 2012).

Interpreting these VIIRS still requires caution. Pipeline construction only brings a short and volatile burst of spending (Barlow, 2020). Increased brightness in regional hubs like Hoima and Buliisa does not necessarily prove real economic integration. Speculative land buying and informal labour migration push people into dense settlements along the project route (Nwapi, 2016). This population growth makes the area brighter at night even if actual industrial linkages never develop. Separating an isolated enclave from real regional growth would mean looking at both the industrial fenceline and the surrounding town networks over several years.

NDVI (Normalised Difference Vegetation Index) measures the contrast between near-infrared reflectance, which healthy canopy reflects strongly, and red-band absorption.

A sustained NDVI drop at an infrastructure site indicates physical clearance. Because the Kingfisher FID provides a clear shock, a difference-in-differences design can compare infrastructure polygons against controls before and after February 2022. The same DiD logic applied to VIIRS at town perimeters then tests whether that construction generated any detectable change in the surrounding settlement network.

This is useful in the Ugandan case. The area around the EACOP development has become increasingly militarised. International NGOs and even institutional investors are often taken to the regional capital Hoima when visiting the controversial EACOP oil project. Local NGOs and activists have faced severe repercussions from both the police and the military when attempting to protest against the development. Field research by Just Finance International (2025a) documented persistent displacement, restricted lake access, and the continued use of force by military units deployed to protect oil infrastructure, conditions that sit alongside the operators' claims of regional economic benefit. Under those conditions such claims are hard to verify on the ground. Night lights and vegetation change do not depend on a guided visit to Hoima. A project with Hirschman linkages should leave a detectable impact on the regional towns after the final investment decision took place in 2022.

3 Data and methods

TotalEnergies has framed EACOP as a source of regional prosperity, yet the enclave literature suggests those claims should not be taken as a given. Verifying them from the ground is difficult. Employment and local procurement data for the lakeshore towns are thin, and official visits along the corridor are often routed to Hoima rather than to the project sites. Because independent ground access is restricted, this study uses satellite data to track the environmental and economic impact of the project thus far.

Two February Sentinel-2 rasters of the Kingfisher site, processed in ArcGIS Pro, give an overview of what changed between 2017 and 2025 around the pads, the Central Processing Facility (CPF), and the shore. They show the shift in water and vegetation across the site. The Tilenga site was not analysed for this initial phase of the research. The Kingfisher oil site has been built on top of an existing human settlement, and protests have been met with permanent deployment of the UPDF in addition to private security. As a result, the local population has experienced documented, significant abuses of their human rights (Just Finance International, 2025a; International Federation for Human Rights et al., 2024).

The second phase of this research attempts to separate long-term trends from the project itself. To do so, monthly panel datasets were built in Google Earth Engine to analyse how both VIIRS and NDVI changed following the February 2022 Final Investment

Decision (FID) relative to rural villages on Lakes Edward and Kyoga. The NDVI panel tracks vegetation loss on the industrial footprint. The VIIRS night-lights panel targets the enclave question, testing whether radiance increased at fenceline towns and in the 15–40 km regional group.

Both the ArcGIS and GEE workflows use the same geometry. Pads, wells, feeder corridors, treatment facilities, and the pipeline route were scraped from the public data on eacopmap.org and saved as GeoJSON. Settlement perimeters for fenceline towns, regional towns, and rural controls were traced by hand in Google Earth around the built outskirts of each place and stored in a KML. I also kept the rural control polygons in a similar size range by eye, so small villages were not mixed with much larger settlements. The 0–15 km and 15–40 km rings (Table 1) are buffers to classify the fenceline and the regional impacts of the project. Layers are kept in WGS84 and reprojected to UTM zone 36N when the data is displayed in metres. WorldPop Global2 was also checked over these zones, but is omitted from the main analysis. This is because it only updates in 2015, 2020, and 2025, with intermediate years modelled from national data, which smooths out the 2022 break.

Table 1: Distance ring areas (metric buffers around scraped infrastructure)

Zone	Radius	Area (km^2)
Fenceline	0–15 km	2,895
Regional	15–40 km	11,071

The two-scene maps were processed in ArcGIS Pro on a desktop. The monthly panels could not be. An 11-year daily VIIRS series and a 6-year Sentinel-2 series across three lakes run to thousands of scenes, so I uploaded the GeoJSON and KML polygons to Google Earth Engine and reduced the pixels there through the Python API. Cloud-masking on Sentinel-2 Level-2A and the polygon means on the daily Black Marble collection were done in the cloud and exported as CSVs. Isolated bright nights on the town series were dropped later in R. I then ran the site–month regressions and the wild-cluster bootstrap in R.

3.1 Sentinel-2 land-cover change (ArcGIS Pro)

The ArcGIS Pro section of this project processes two February Sentinel-2 scenes of the Kingfisher AOI (2017 and 2025) into water-change and NDVI-change maps. The AOI covers about 3,300 km^2 of persistent land across the Kingfisher area.

Primary inputs are Sentinel-2 Level-1C (top-of-atmosphere) tiles from the ESA Copernicus programme for 7 February 2017 and 25 February 2025 (European Space Agency, 2024; Drusch et al., 2012). The GEE NDVI panel uses Level-2A surface reflectance (Section 3.2.1). February is in the dry season and was chosen to reduce cloud cover over the lakeshore. Blue (B2), Green (B3), Red (B4), and Near-Infrared (B8) were processed at 10 m for both dates. Matching both dates to February helps to control for seasonality.

For each date I compute NDWI and treat pixels above 0.1 as water, following McFeeters (1996). Comparing the 2017 and 2025 water masks gives four change classes: persistent land, new water, persistent water, and lost water. The NDVI change map is limited to pixels that were land in both years; this controls for the fact that a large shift in surface type can move the index when plants are not what changed. A shoreline pixel that was water in 2017 and dry ground or sparse cover in 2025 can yield a large positive ΔNDVI simply because open water and bare shore return different NIR and red values. Land flooded into water can look like vegetation loss when the real change is flooding. Restricting the difference map to persistent land keeps those water-to-land changes out of the vegetation totals. On those pixels I take the continuous NDVI change and create the following bins: significant loss (< -0.25), moderate loss (-0.25 to -0.1), no significant change (-0.1 to 0.1), moderate gain (0.1 to 0.25), and significant gain (> 0.25).

3.2 Panel difference-in-differences in GEE

I extract both panels in Google Earth Engine, calling the API from Python, and estimate them in R with `fixest`. February 2022 is the common break. I compare how much the treated sites moved after FID with how much the Edward and Kyoga villages moved over the same months. Site fixed effects absorb permanent differences between places; time fixed effects absorb shocks common to every site in a given month, including national 2022 fuel-price and post-COVID timing that hits Albertine towns and the Edward/Kyoga controls alike. The remaining coefficient is the post-2022 change at the fenceline and regional towns versus the controls.

The rural controls began as seventeen candidates across Lakes Edward, Kyoga, and Victoria. The main sample keeps eight small Edward and Kyoga lakeside villages, selected on distance from the pipeline and from Kampala, and on OSRM driving time to the Kingfisher Development Area. These controls were selected very conservatively. The current cost of the pipeline sits at roughly 7 per cent of Uganda's GDP. A figure of that size is likely to have some uniform impact across the country. To account for this, the selected controls are screened to ensure that they are sufficiently far from both the development and the capital city (Kampala). To test for distance from the oil site OSRM drive time is used. Controlling for proximity to the capital was achieved by removing all sites on Lake Victoria; these Victoria sites have a higher probability of being affected by some other confounding variable.

Figure 1 shows the seventeen against the pipeline and Kampala. Table 2 lists those eight with area, Kampala km, infrastructure km, and OSRM minutes. Both GEE models use those eight. The full set is in Annex Table 8. The annex also re-runs the town DiD on the four of the eight with the longest OSRM drive times. Hoima (oil-region capital) and the peer cities Gulu and Masaka are held out of the rural arm; Figure 9 shows their VIIRS trajectories as a descriptive check on that choice.

Control candidates and industrial geometry (Uganda)

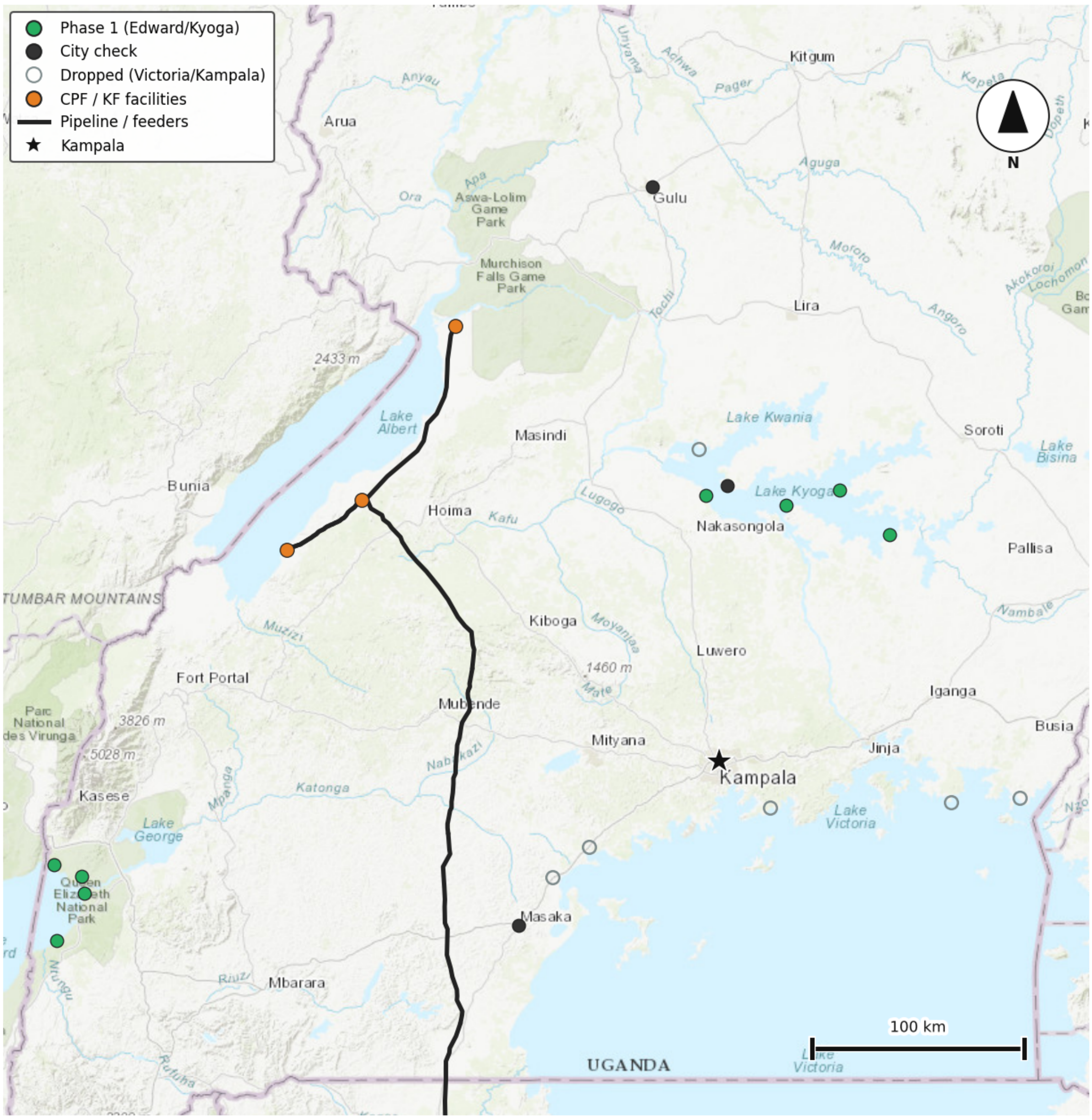


Figure 1: Control candidates and corridor geometry.

3.2.1 NDVI at infrastructure

The NDVI panel is extracted from Sentinel-2 Level-2A using the Google Earth Engine API at daily resolution. Treated units are oil-pad and feeder/CPF polygons; controls are the eight rural villages.

Cloudy pixels are masked out. On what remains I compute the usual NDVI, (NIR − red)/(NIR + red), from bands B8 and B4 at 10 m. For each site and date I keep the mean

Table 2: Eight rural controls used in both GEE DiDs

Site	Lake	Area (km^2)	Kampala km	Infra km	OSRM min
Rwenshama	Edward	0.66	323	211	362
Kazinga	Edward	0.32	305	185	305
Katwe	Edward	3.48	305	179	284
Kabahango	Edward	0.34	317	182	277
Okwangalete	Kyoga	0.52	140	189	530
Zengebe	Kyoga	0.79	126	134	306
Bukungu	Kyoga	0.89	125	169	509
lyingo	Kyoga	0.42	134	219	466

Infra km is crow-flies distance to the scraped industrial union. OSRM min is driving time to the Kingfisher Development Area.

of those clear-pixel values inside the polygon, and the share of the polygon that was clear. I drop any date where less than half the polygon is clear, then take the median NDVI for each site and month. Before 2019 there is little usable coverage after masking, so the main sample runs 2019–2025 (4,351 site–months across 52 sites: pads, feeders, and the eight controls).

I estimate

$$\text{NDVI}_{it} = \beta(\text{Industrial}_i \times \text{Post}_t) + \alpha_i + \gamma_t + \varepsilon_{it}, \tag{1}$$

where NDVI_{it} is the monthly median index at site i in month t. Industrial_i equals 1 for pads and feeders and 0 for the rural controls; Post_t equals 1 from 2022. α_i and γ_t are site and year–month fixed effects, and ε_{it} is the residual. β captures the post-2022 NDVI change at industrial sites relative to the controls, with standard errors clustered by site. Pads and feeders are also estimated separately. An event-study specification omitting 2021 tests for pre-trends prior to FID.

I also split the industrial polygons by crow-flies kilometres to the CPF/KF core used for the 15 km rings, and compare sites inside and outside that cut against the rural controls. Among industrial sites alone I also interact post-2022 with continuous distance.

3.2.2 VIIRS nightlights

Night lights (2014–2025) come from the daily NASA Black Marble dataset (VNP46A2) in Google Earth Engine. Daily radiance over Lake Albert is noisy due to clouds, gas flaring, and sensor artefacts (Román et al., 2018). On non-industrial sites I drop isolated bright nights (the same screen on fenceline, regional, and rural polygons). In cases where a site has at least thirty pre-2022 clear days I take that pre-FID median, MAD, and 99.9th percentile; otherwise I use the full series. A night is flagged if radiance exceeds both the median plus eight times the MAD and the 99.9th percentile, and neighbouring nights (±1–2 days) are not also above the threshold. Pads and feeders are left out of that spike screen so sustained construction and facility lighting remain in the industrial series. Filtered daily values are averaged inside each polygon and collapsed to monthly means (3,306 site–months across 23 sites). Weekly panels are kept as a check.

The main sample includes 23 sites: nine fenceline towns (< 15 km), six regional towns (15–40 km), and the eight rural controls. Pads and feeders are analysed separately to verify industrial lighting. Towns are classified by straight-line distance from their centroid to the nearest infrastructure (Table 1), placing Tonya (15.3 km) and Runga (40.9 km) in the regional group. Full site rosters appear in Tables 7 and 9.

To test whether economic activity spread beyond the extraction site after the February 2022 FID, I estimate:

$$Y_{it} = \beta_1(\text{Fenceline}_i \times \text{Post}_t) + \beta_2(\text{Regional}_i \times \text{Post}_t) + \alpha_i + \gamma_t + \varepsilon_{it}, \quad (2)$$

where Y_{it} is mean radiance at site i in month t. Fenceline_i marks the nine towns within 15 km, Regional_i marks the six towns between 15 and 40 km, and the eight rural villages are the control group. Post_t turns on in 2022. α_i is a site fixed effect, γ_t is a month fixed effect, and ε_{it} is the error term.

β_1 estimates the extra post-2022 brightness in fenceline towns relative to rural controls, whilst β_2 estimates the change in regional towns. If the oil project created regional growth, β_2 should be positive. A pooled Albertine × Post specification that treats the same fifteen lakeshore towns as one treated group against the same eight rural controls is reported alongside the split in Table 6. Standard errors are clustered by site and confirmed using a 999-replication Rademacher wild-cluster bootstrap (both WCR and WCU) on the split. The annex reports site-specific linear trends, annual event studies, alternative control pools, leave-one-out on the eight controls and on each fenceline town, and a drop of the two settlements within 3 km of infrastructure (Kigwera and Buliisa).

4 Results

All estimates run on the shared eacopmap geometry, with the February 2022 FID as the break.

4.1 Sentinel-2 land-cover change

Between February 2017 and February 2025, oil development transformed life around Lake Albert. The maps created show that of the 3,330.24 km^2 of land that stayed dry in both scenes there was 1,047.15 km^2 of vegetation loss and 147.19 km^2 of newly mapped open water, alongside 1,583.60 km^2 of persistent lake surface and 5.22 km^2 where water retreated (Tables 3 and 4; Figures 2 and 3).

Table 3: Water surface change, Kingfisher AOI (2017–2025)

Class	Area (km^2)
Persistent land	3,330.24
New water	147.19
Persistent water	1,583.60
Lost water	5.22

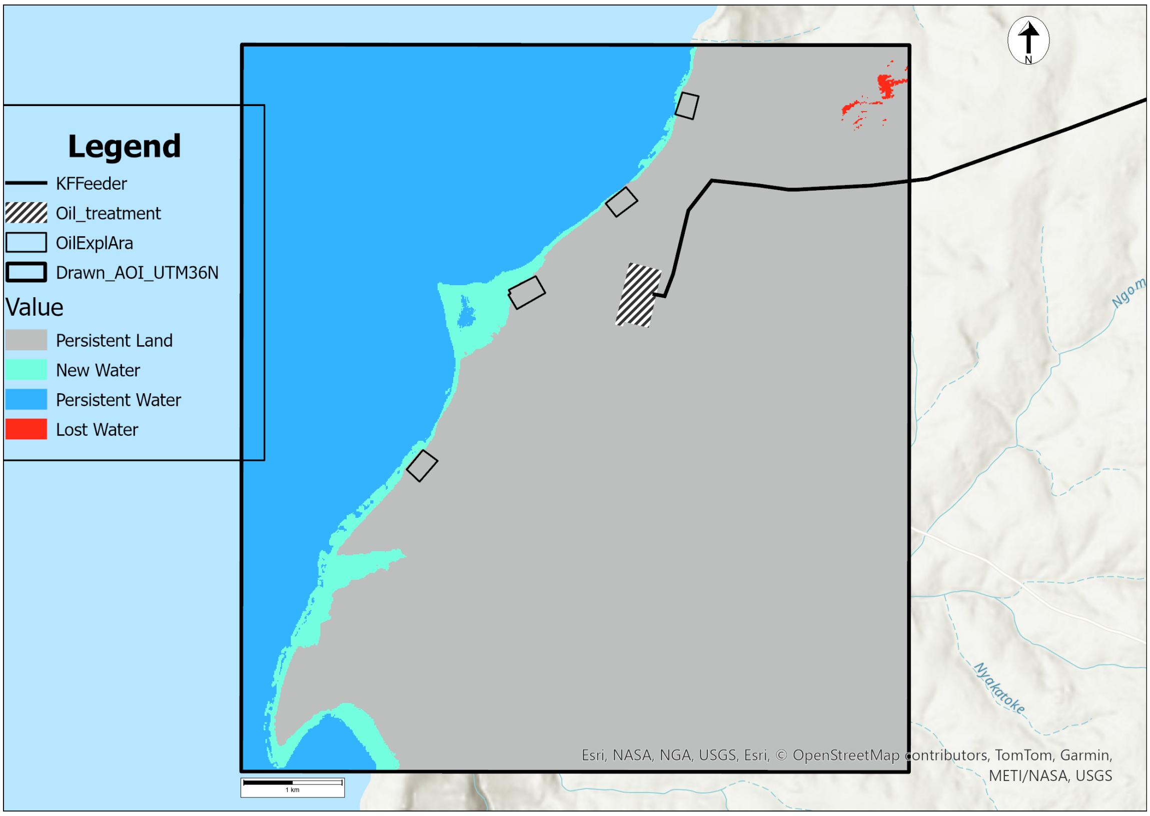


Figure 2: Water surface change in the Kingfisher AOI (2017–2025).

Most of that $147.19\,km^2$ of new water (about 2.9% of the AOI) sits on the Lake Albert shore; with the drawn AOI covering only some $51\,km^2$. The pads, ditches, and CPF retention ponds cannot plausibly generate this much water change. Boergens et al. find a large rise in water storage across the East African Rift around 2019–2020, with Lake Albert rising alongside Kyoga downstream of Victoria (Boergens et al., 2024). The expansion we see here is likely consistent with that rise in water level, and with the wider rise across the Great Lakes over 2019–2024 – though with only two February scenes I cannot fully separate seasonal flooding from lasting inundation.

On the land that stayed dry in both scenes, vegetation loss exceeds gain (Table 4). The strongest loss sits at the main industrial footprint, mostly on the pads and the CPF, with further loss along roads and pipeline corridors and scattered patches in the southern AOI. Vegetation gain is patchy and mostly inland; most of the plain away from the corridors stays in the no-change class. Field reporting on clearance in the Buhuka Flats (Just Finance International, 2025a) describes the same clearance.

Table 4: NDVI change on persistent land (2017–2025)

Class	Area (km^2)
Significant vegetation loss	283.84
Moderate vegetation loss	763.31
No significant change	1,911.14
Moderate vegetation gain	304.37
Significant vegetation gain	67.58

On persistent land, 57.4% shows no significant change, 31.4% falls into a loss class, and 11.2% into a gain class; significant loss alone is 8.5%. The AOI shows a net NDVI drop between the two February scenes. Blocks and strips next to mapped facilities match the clearance and compacted ground visible in Figures 4a–4b. Inland change can come from farming, fire, or differences between the Level-1C scenes.

Figures 4a–4b show the same change in false colour. In 2017 the area is still relatively green, with little large infrastructure. By 2025 the airstrip and industrial block are clear and roads cut across the flats, with geometric clearings at the pads near the facilities. The shoreline by the central development is sharper in places.

Clearance sits on pads, the CPF, and road and pipeline corridors, whilst much of the inland AOI stays in the stable NDVI class; yet the ArcGIS inputs are Level-1C (top-of-atmosphere) and only a single February pair, so the two-scene maps locate the industrial strip but leave the timing against the February 2022 FID to the L2A monthly panel below.

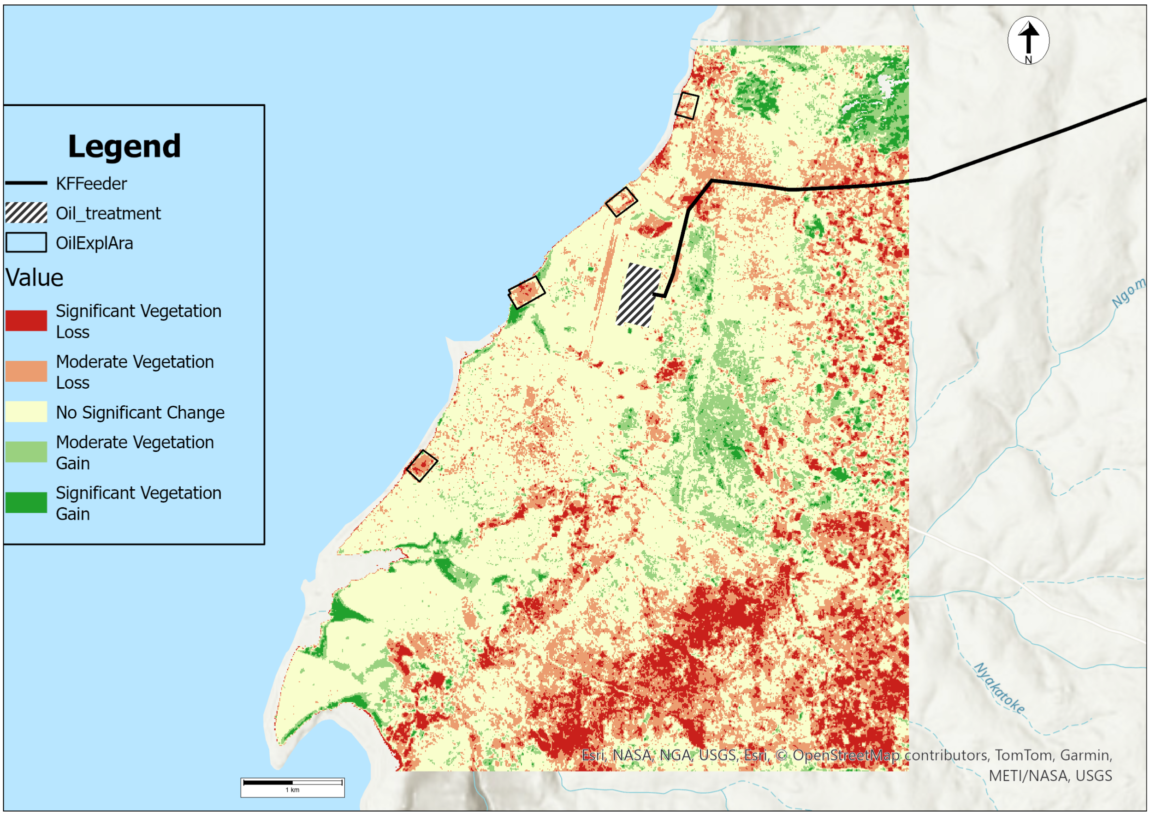
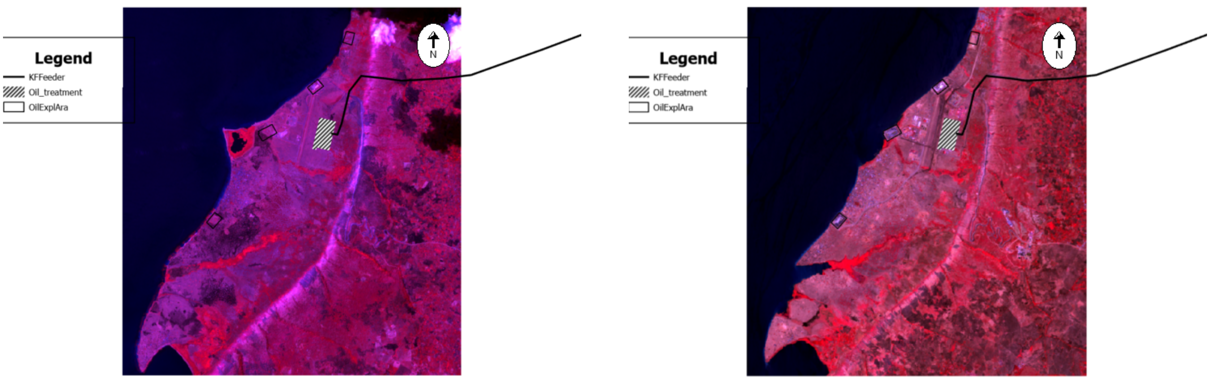


Figure 3: Vegetation change on persistent land.



(a) February 2017

(b) February 2025

Figure 4: False-colour vegetation composites (NIR-Red-Green).

4.2 NDVI timing at infrastructure

The two-scene Sentinel-2 maps above show where clearance occurred on the Buhuka flats, but they only compare two single dates. To test the impacts against the FID, the monthly Sentinel-2 Level-2A panel compares NDVI across 52 polygons from 2019 to 2025.

Figure 5 and Table 5 show industrial and control NDVI staying together through 2021, then the industrial series falling after FID. This flat pre-trend indicates that the decline in NDVI began with the post-FID construction phase.

On its own, a drop in vegetation at a construction site is not interesting. However, the NDVI panel serves two specific purposes. First, the flat pre-2022 series confirm that heavy ground preparation coincided with the February 2022 FID rather than a longer historical trend. Second, comparing the industrial footprint against the controls shows that this loss was driven by project clearing rather than a regional climatic shift across Uganda's lakes.

Table 5 reports the difference-in-differences estimates. Across the full panel, monthly NDVI on the industrial polygons falls by 0.101 after the February 2022 FID relative to the rural control villages. When pads and feeders are estimated separately, well pads drop by −0.098 whilst feeder corridors and the CPF drop by −0.142.

The larger drop on the feeders matches the work on the ground. Building pipeline corridors, drainage ditches, and haul roads requires clearing continuous strips of land across the flats, whereas individual drilling pads have smaller, more compact footprints. On the NDVI scale, a drop of 0.101 is a large loss of vegetation, replacing scrub and grassland with bare ground and gravel pads.

Table 5: NDVI DiD, infrastructure versus rural controls. Monthly median NDVI by polygon; primary sample 2019–2025; clear-pixel share $\geq 50\%$.

	Coefficient
Infrastructure × Post-2022	-0.101^{***}
	(0.019)
Site FE / Month FE	Yes
Observations (site-months)	4,351
Sites (clusters)	52

Standard errors clustered by site. $^{***}p < 0.01$. Treated units are oil pads and feeder/CPF polygons; controls are the eight rural villages.

Figure 5 plots the series. Before 2022, NDVI and night lights move in parallel across both groups. After FID, the industrial sites diverge, greenness drops as land is cleared, whilst radiance rises as work lights and generators switch on. The rural control villages remain flat on both measures throughout.

Clearing and extra lighting stays at the industrial footprint. However, NDVI only measures surface stripping on the concession itself. Whether that construction generated

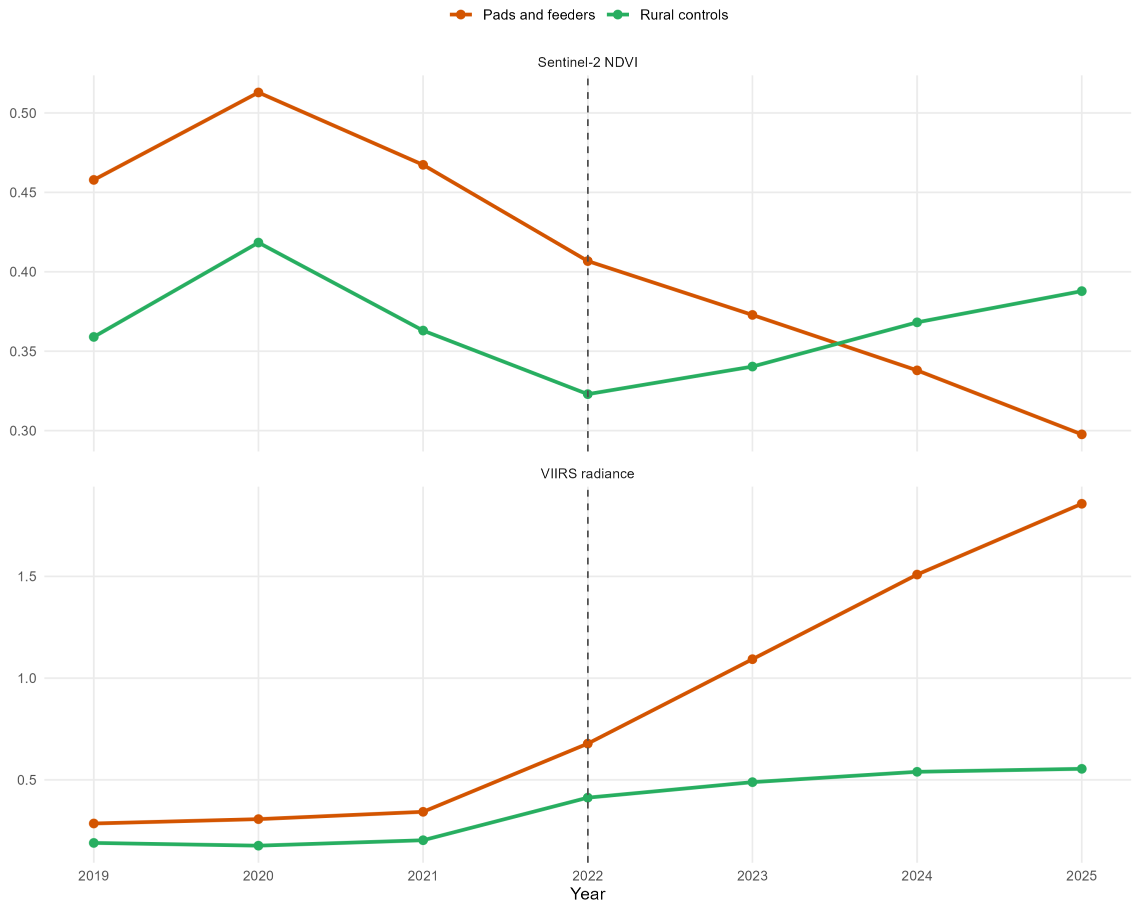


Figure 5: Pads and feeders versus eight rural controls. Annual means of monthly polygon NDVI (top) and VIIRS radiance (bottom), 2019–2025. Dashed line marks 2022.

wider economic spillovers requires night-lights.

4.3 VIIRS: fenceline activity and the regional band

TotalEnergies cast EACOP as a project of "shared prosperity" and "positive local return" (TotalEnergies, 2022b). CNOOC's Uganda president projected \$1.6 billion in in-country value for Kingfisher and as many as 160,000 jobs from the Lake Albert development (Energy Voice, 2022), whilst UNOC credited sector linkages with over 160,000 oil-sector jobs and a \$8.6 billion GDP gain (Banage, 2024). Thus far these claims are not reflected in the night-light data.

Figure 6 shows mean monthly VIIRS radiance across the three main groups from 2014 to 2025. Before 2022 the three group means move together; after 2022 the fenceline series pulls away whilst the regional line stays with the rural controls (Figure 6). Pads and feeders, which are excluded from the town regression, show an even steeper post-2022 jump, confirming that the initial surge in luminosity originated on the industrial facilities themselves.

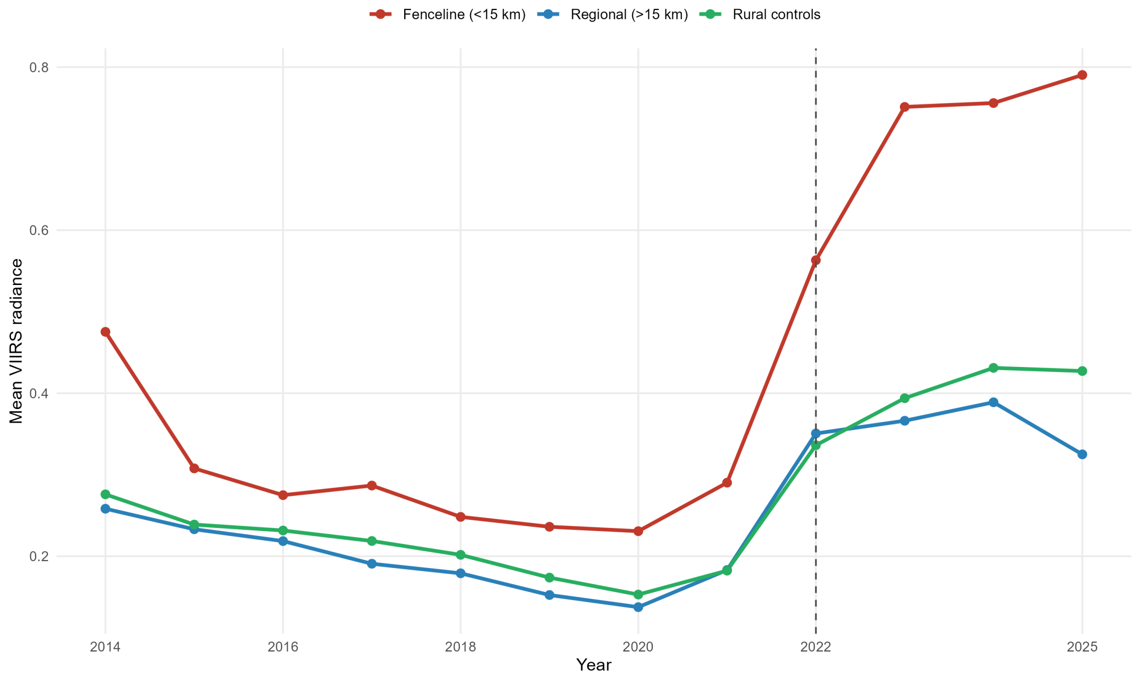


Figure 6: Parallel trends: mean VIIRS radiance by group.

Table 6 reports the difference-in-differences estimates. Column (1) is the headline split: the fenceline post-2022 coefficient is $+0.245$ (SE 0.113, $p \approx 0.042$); the regional coefficient is -0.026 (SE 0.041, $p \approx 0.53$). A wild-cluster bootstrap with 999 replications confirms that the fenceline gain is statistically significant, while the regional estimate remains indistinguishable from zero. Column (2) pools all fifteen lakeshore towns and asks whether the Albertine corridor as a whole brightened after FID. The answer is no,

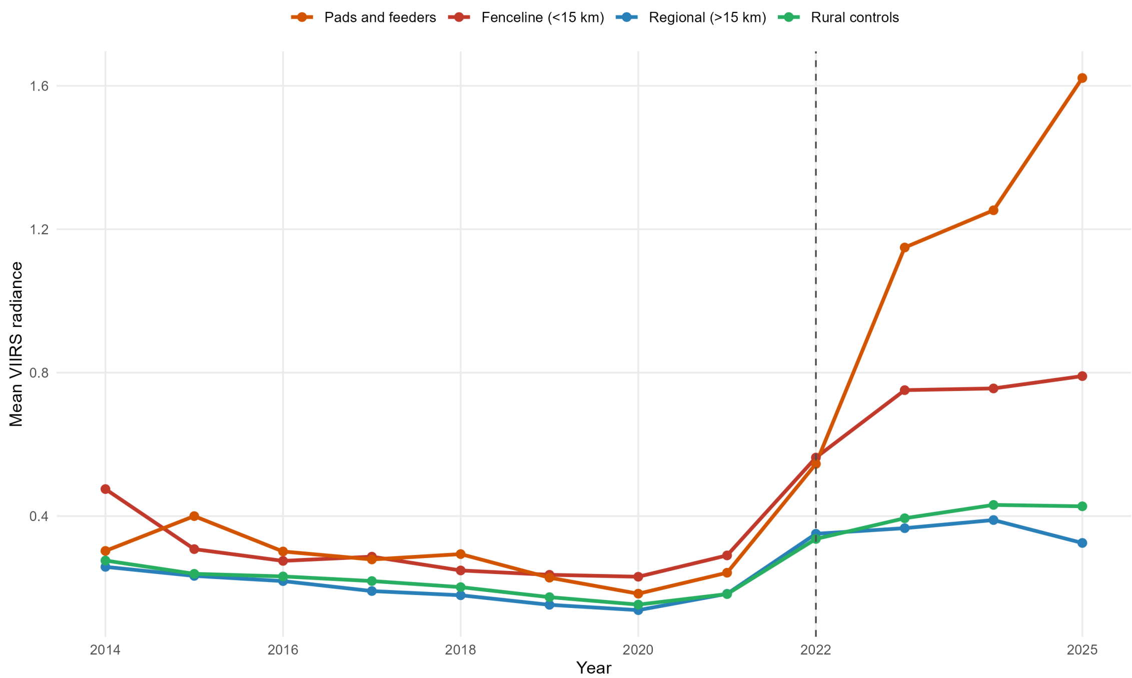


Figure 7: Industrial validation: pads and feeders versus rural controls.

the pooled coefficient is +0.136 (SE 0.081, $p \approx 0.11$) and not statistically significant. The wider corridor tests fail in both specifications. After FID, only the fenceline towns brighten significantly; the regional towns and the pooled fifteen-town average do not. It is importnat to note that much of the fenceline 'gain' is facility glare and camp security lighting bleeding into Kigwera and Buliisa, the only settlements within 3 km of the oil facilities (Annex Table 10).

Table 6: VIIRS DiD, monthly town panel, all rural controls. (1) Split by distance band. (2) Pooled Albertine (15 towns).

	(1) Split	(2) Albertine
Fenceline (< 15 km) $\times$ Post-2022	0.245**	
	(0.113)	
Regional (> 15 km) $\times$ Post-2022	−0.026	
	(0.041)	
Albertine $\times$ Post-2022		0.136
		(0.081)
Site FE / Month FE	Yes	Yes
Observations	3,306	3,306
Sites (clusters)	23	23

Standard errors clustered by site. $^{*}p < 0.10$, $^{**}p < 0.05$. Column (2) pools the nine fenceline and six regional towns; empty cells are not in that specification.

The difference between the fenceline estimate (+0.245, $p \approx 0.042$) and the regional estimate (-0.026, $p \approx 0.53$) shows where the construction activity actually took place. If the project had generated backward linkages in the surrounding district, worker spending and subcontracting would have reached market towns like Butiaba, Tonya, and Runga, lifting their night lights relative to the unexposed Edward and Kyoga controls. The brightness in the satellite series stays on the 15 km fenceline, where drilling rigs, generator-powered worker camps, and security floodlights sit directly on the lakeshore flats. Outside that perimeter, regional towns show no post-2022 radiance gain.

Dropping each fenceline town one by one keeps the post-2022 coefficient positive across each iteration (ranging between 0.17 and 0.30 in Annex Table 10), showing that the result is not driven by a single outlier settlement. However, dropping Kigwera and Buliisa together—the only two towns within 3 km of the oil facilities—reduces the estimate to 0.18 ($p \approx 0.10$). This suggests that a portion of the fenceline brightness comes from industrial floodlights and facility glare bleeding directly into neighbouring settlements rather than independent village growth. Outside that immediate perimeter, the six regional towns show no post-2022 gain across any specification, including weekly panels and models with site-specific linear trends (Annex Table 11). Figure 8 maps the fifteen Albertine town polygons against the CPF/KF footprint; Kigwera and Buliisa are the only settlements within 3 km of the industrial union.

Figure 9 compares Hoima against Gulu and Masaka across the same 2014–2025 VIIRS extraction. Because regional cities operate on a much higher baseline radiance than the lakeshore fishing villages (Masaka starts near 4.25 in 2014, whereas rural controls remain below 0.5), they are excluded from the DiD and serve as a descriptive check on urban growth. Over the full series, mean radiance rises from 1.70 to 4.86 in Hoima (+185%), from 0.85 to 4.17 in Gulu (+389%), and from 4.25 to 7.75 in Masaka (+82%).

Hoima grows substantially, but it does not outpace its peers after the 2022 FID, lagging Gulu on the same trajectory. If extraction had turned the regional capital into an oil boomtown, we would expect to see Hoima pull away from the other two cities. Instead, its growth seems to track the national baseline. This matches what Phelps et al. (2015) describe in their Chilean copper cases; the host region retains the physical mine whilst specialised labour and technology bypass the regional centre for the capital city. Combined with the flat coefficient on the 15–40 km band in Table 6, we see a result that aligns with what Appel (2019) describes as a modular enclave. Despite the fact that official delegations and corporate visitors are routinely taken to Hoima to demonstrate regional progress, night lights over the town look no different from ordinary city expansion.

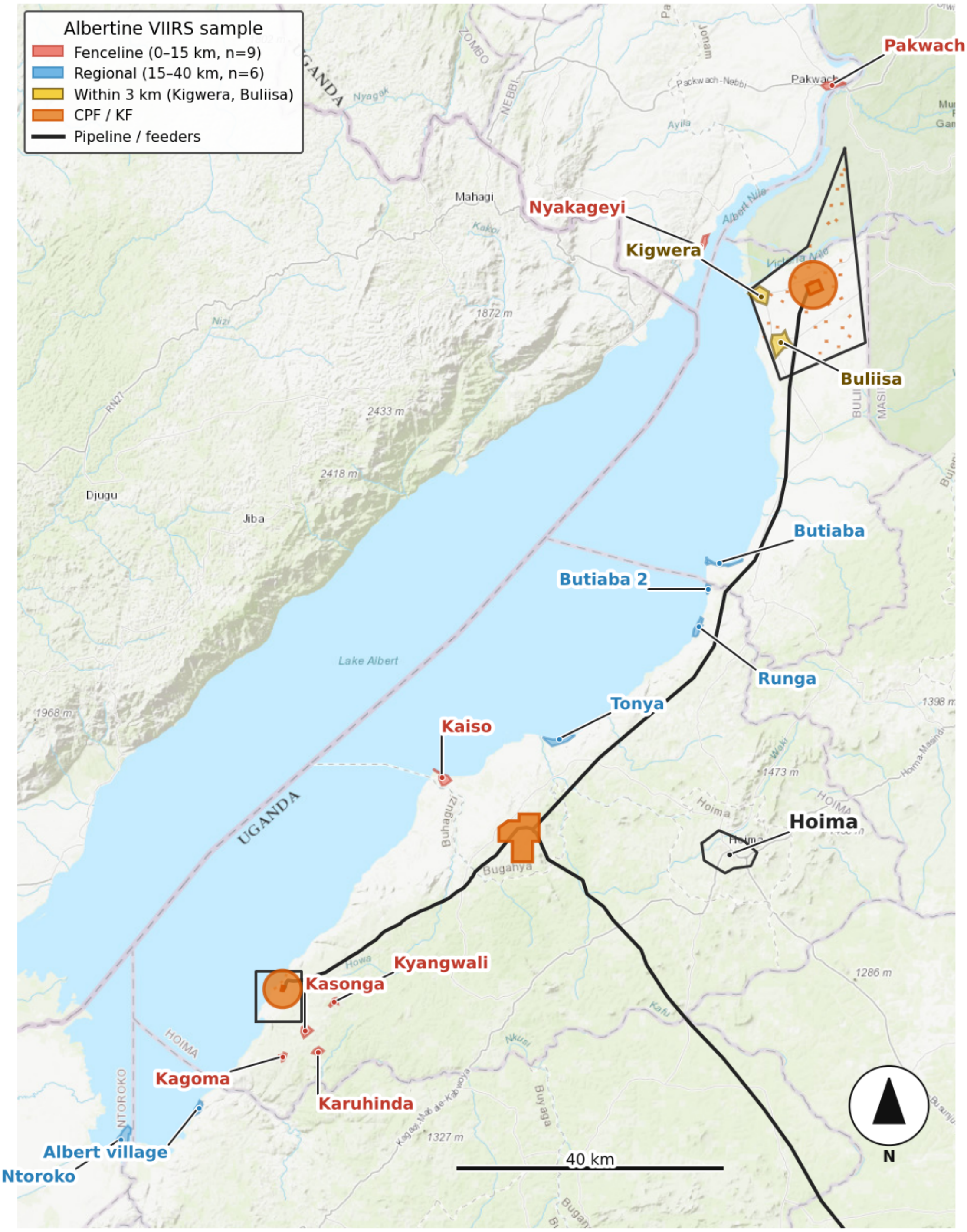


Figure 8: Albertine VIIRS sample. Hand-traced town polygons from `eacop.kml`. Red fill: fenceline towns (0–15 km). Blue fill: regional towns (15–40 km). Yellow fill: Kigwera and Buliisa, within 3 km of CPF/KF. Black line: EACOP pipeline and KF/Tilenga feeders; orange: oil pads and CPF/KF.

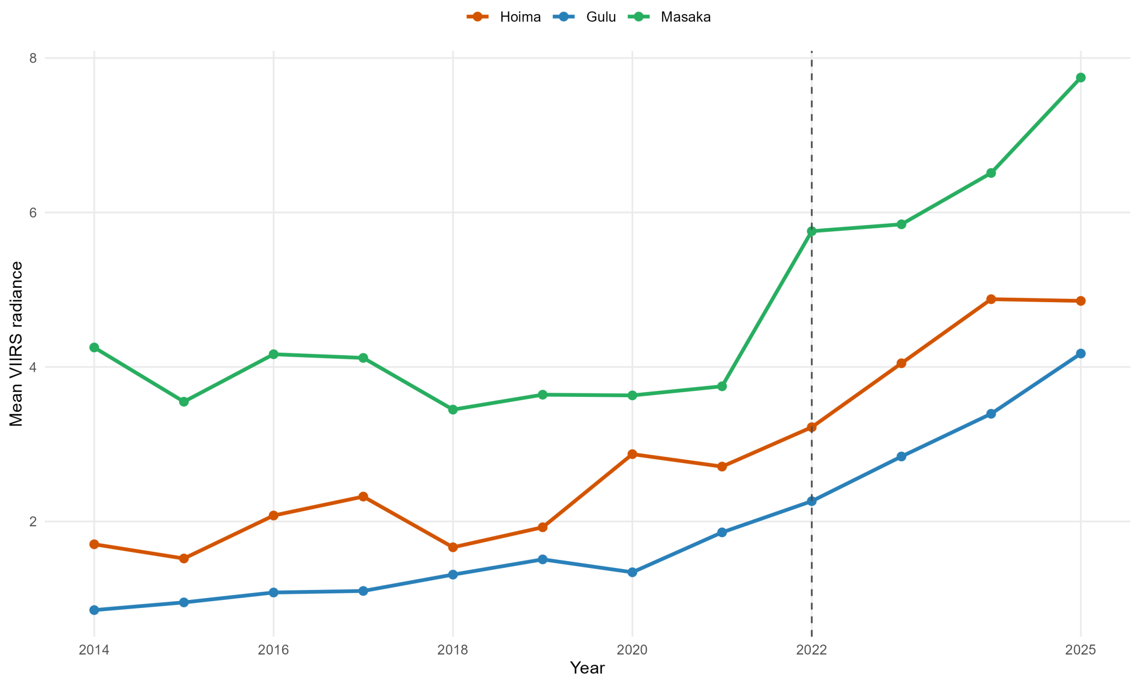


Figure 9: Urban benchmark: mean VIIRS radiance, Hoima versus Gulu and Masaka (site-year). Dashed line marks 2022.

4.4 Dual-sensor reading

Figure 8 shows the main-sample sites; Figure 10 shows the 0–15 km / 15–40 km rings from Table 1 (2,895 km^2 fenceline against the 51 km^2 scraped industrial corridor). Pad-level NDVI distance decay, the OSRM radiance gradient, and the annual event study with site trends are reported in Annex A.9.

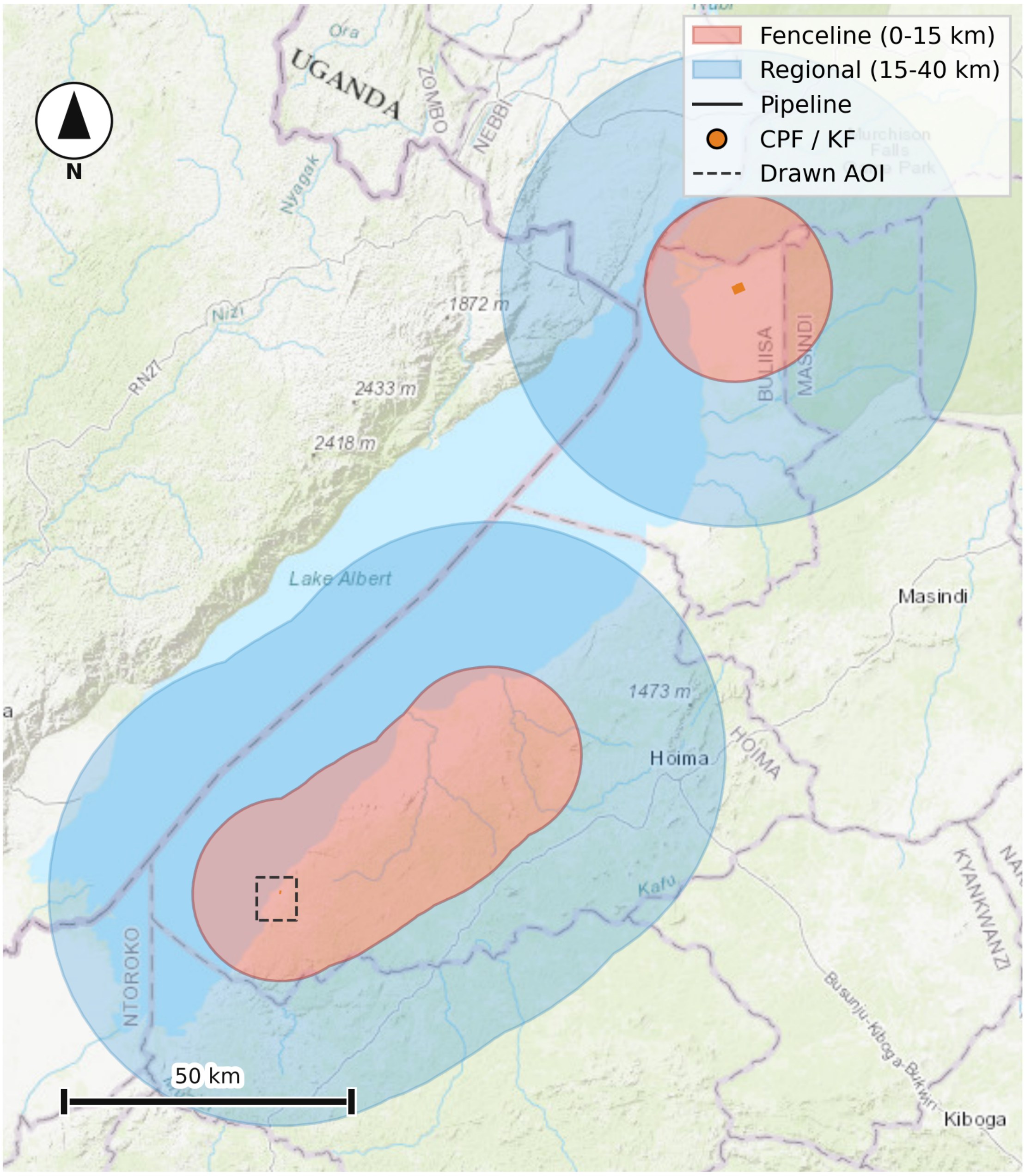


Figure 10: Distance rings from Kingfisher infrastructure union (0–15 km and 15–40 km).

The ArcGIS maps place clearance on the industrial geometry and set most of the new-water class on the rising lake shore. The L2A NDVI panel dates the greenness loss on pads and feeders to the post-2022 window. The VIIRS split lifts the fenceline within 15 km against Edward and Kyoga, whilst the six regional towns do not follow. A story built on Hirschman's backward linkages would look different, with land-cover change spreading into lakeshore settlements beyond the pads and roads and with the 15–40 km towns lifting alongside the fenceline as regional demand took hold. In the present sample neither happens. The 10 m optical scenes and the 500 m night lights place clearance and extra lighting at the lakeshore site itself, the spatial pattern the enclave literature in Section 2 would predict (Just Finance International, 2025a; International Federation for Human Rights et al., 2024).

5 Conclusion

5.1 Summary

This mémoire set out to test whether the observable satellite footprint of Kingfisher construction stayed near infrastructure or spread into the surrounding settlement system. The ArcGIS Sentinel-2 maps for 2017–2025 show about 147 km^2 of newly mapped open water, mostly Lake Albert shoreline rise, and 1,047 km^2 of vegetation loss on persistent land, with loss at the CPF, pads, and road corridors. The GEE NDVI DiD for 2019–2025 gives a post-2022 decline of about -0.10 at the industrial site compared to the controsl. On VIIRS for 2014–2025 the fenceline interaction is $+0.245$ and remains significant under a wild-cluster bootstrap, whilst the regional interaction stays close to zero at -0.026. Pooling all fifteen Albertine towns still fails to produce a significant corridor-wide rise ($+0.136$, $p \approx 0.11$).

A story built on Hirschman's backward linkages would look different. Under this case we would see clearance spreading into lakeshore settlements beyond the industrial geometry, and the 15–40 km towns lifting with the fenceline as regional demand took hold. In the present sample neither happens. The change in night lights stays inside the 15 km fenceline. This is the spatial pattern the enclave literature in Section 2 would predict.

5.2 Limits

Whilst the limitations of this study are numerous, three matter most for how the results should be read. Night lights record radiance. They do not record jobs, contracts, or household incomes. At Kingfisher the signal is further contaminated by military camps (Just Finance International, 2025a) and by industrial floodlights bleeding into nearby town polygons. Dropping Kigwera and Buliisa, the two settlements within 3 km of the main facilities, leaves the fenceline coefficient at about 0.18 ($p \approx 0.10$). The full-sample estimate therefore mixes facility bloom with ordinary town light. That still places the radiance on the extraction footprint, but it complicates any welfare reading of the coefficient.

The VIIRS panel is also small: 23 site clusters, nine of them fenceline, only six regional, and eight rural controls. With a minimum detectable effect of about 0.11, the regional null bounds large spillovers in this sample rather than proving a zero effect. Pooling the fifteen Albertine towns shows that this is not simply an artefact of the 15 km cut. The fenceline estimate is more fragile under alternative controls. Widening the pool to every non-city candidate collapses that coefficient to -0.019 (Table 9), because the expanded set brings back the Victoria-corridor villages that Section 3 dropped for sitting too close to Kampala or the pipeline. The eight Edward and Kyoga villages remain the main counterfactual for that reason. Towns are classified into fenceline and regional groups by straight-line distance to nearest infrastructure; OSRM enters the design as a screen on the rural controls and as an annex robustness check.

Finally, the ArcGIS change maps used Level-1C top-of-atmosphere tiles. The NDVI difference map absorbs some atmospheric variation through the band ratio, but water classification remains sensitive to path radiance, so the 147 km^2 of newly mapped open water is best treated as an order-of-magnitude shoreline expansion. The GEE NDVI and VIIRS panels sit on Level-2A and Black Marble products respectively, and the timed DiDs inherit those product qualities. Separately, the annual VIIRS event study in Annex A.9 is imprecise since the post-2022 confidence bands are wide and cross zero. The monthly difference-in-differences in Table 6 times the radiance shift to FID.

5.3 What the mémoire contributes

This mémoire contributes primarily through its geomatics design. Whilst a considerable amount has been written on enclaves and on night lights as activity proxies, empirical work that carries one infrastructure layer through both optical change detection and VIIRS radiance on the same corridor remains limited. To this, the industrial scrape from `eacopmap.org`, the Google Earth settlement perimeters, and the rural controls are held fixed across ArcGIS Pro, GEE, Python, and R, so that treatment locations do not silently drift across sensors.

The empirical contribution is the regional radiance coefficient. Hirschman predicts that a shock of this size should generate a regional boom. The enclave and modularity literatures predict the opposite: activity stays at the fenceline whilst supply contracts bypass the host district. The null regional coefficient supports the latter. The physical footprint expands; the wider settlement band does not pull away with it in night lights.

The same design can be taken to other corridors. Rerunning it on the EACOP route through Tanzania, or on Tilenga further north, needs a datable shock (FID or construction start), digitised infrastructure, settlement perimeters at varying distances, and rural controls on a separate water body. The GEE scripts accept new geometries and the R code is generic, so the timed panels scale. The ArcGIS branch is less portable: it needs a Pro licence, manual classification, and visual checks a script cannot capture.

5.4 Outlook

Whilst further work could push the ArcGIS branch onto Level-2A tiles, assign treatment by drive time, and join survey or administrative outcomes where they exist, the present evidence already points to an enclave-style pattern: local disturbance, and no large regional radiance response in this sample.

The operators' prosperity claims for Kingfisher are currently being contested in French Duty of Vigilance proceedings. TotalEnergies defended its Ugandan and Tanzanian operations as "National Interest Projects decided by the governments of Uganda and Tanzania" (TotalEnergies, 2022a). The original case was dismissed on procedural grounds in February 2023 without a ruling on the merits (BHR Law, 2023). A refiled case remains active, with the Paris court ordering disclosure of internal vigilance-plan documents in September 2025 (Les Amis de la Terre France, 2025). No French court has yet ruled on whether the project's socio-economic claims are accurate.

The VIIRS null on the regional towns sits alongside that unfinished litigation as an independent data point. Field reporting on the Kingfisher Development Area (Just Finance International, 2025a) shows that corporate self-reporting on human rights and environmental compliance often diverges from conditions on the ground. When military deployment and restricted access prevent independent verification, remote sensing offers a check against physical reality that does not depend on a guided visit to Hoima. It cannot replace field, legal, or household evidence (United Nations Human Rights Council, 2025). What this mémoire supplies is an account, reproducible from the shared geometry and the public imagery, of where the surface and night-time activity actually changed during construction.

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A Appendix

A.1 VIIRS site roster (23 main-sample sites)

Table 7 lists the main DiD sample from `Final_Analysis.R`. Groups follow that roster (nine fenceline, six regional, eight rural controls). Distances are crow-flies kilometres to nearest infrastructure from `SITE_INFRA_DISTANCES_V2.csv`. Tonya is assigned regional at 15.3 km. Rural controls listed here are all eight villages used in the headline regression; Table 11 reports the OSRM low-access screen (four sites). Table 8 lists all seventeen `cntrls` candidates. Table 9 reports the same site–month split on alternative control pools.

Table 7: VIIRS main-sample site roster

Site	Group	Dist. infra (km)
Kigwera	Fenceline	1.6
Buliisa	Fenceline	2.2
Kasonga	Fenceline	6.9
Kyangwali	Fenceline	7.9
Kagoma	Fenceline	8.7
Pakwach	Fenceline	10.4
Karuhinda	Fenceline	10.7
Nyakageyi	Fenceline	12.7
Kaiso	Fenceline	14.5
Tonya	Regional	15.3
lake albert small village	Regional	19.1
Ntoroko-cntlr	Regional	30.4
Butiaba	Regional	34.4
Butiaba_2	Regional	38.5
Runga	Regional	40.9
Zengebe	Control	133.6
Bukungu	Control	168.8
Katwe	Control	179.0
Kabahango	Control	181.9
Kazinga	Control	185.1
Okwangalete	Control	188.9
Rwenshama	Control	211.2
lyingo	Control	218.7

A.2 Seventeen control candidates

Table 8 lists all seventeen control candidates. Eight Edward and Kyoga villages enter the main DiD; Gulu and Masaka are secondary cities held out of the rural DiD (Figure 9); Namasale is a Kyoga town too large to pool with the villages; the six Victoria-shore candidates sit too close to Kampala or to the pipeline corridor. Distances to Kampala use KML centroids; OSRM minutes are driving time to the KDA.

Table 8: Seventeen control candidates: eight Edward/Kyoga villages (main sample), three cities (descriptive check), six Victoria-corridor/Kampala-belt sites (benchmark)

Site	Belt	Settlement	Kampala km	OSRM min	Role
Rwenshama	Edward	village	323	362	Control
Kazinga	Edward	village	305	305	Control
Katwe	Edward	village	305	284	Control
Kabahango	Edward	village	317	277	Control
Okwangalete	Kyoga	village	140	530	Control
Zengebe	Kyoga	village	126	306	Control
Bukungu	Kyoga	village	125	509	Control
lyingo	Kyoga	village	134	466	Control
Gulu	North	secondary city	272	336	City check
Masaka	Victoria	secondary city	122	394	City check
Namasale	Kyoga	lakeshore town	130	424	City check
Katosi	Victoria corridor	landing	32	341	Benchmark
Kayabwe	Victoria corridor	highway town	73	346	Benchmark
Lukaya	Victoria corridor	highway town	96	367	Benchmark
Bwondha	Victoria east	landing	111	439	Benchmark
Kawempe	(named metro)	named division	148*	328	Benchmark
Busiro	(named metro)	named county	143*	467	Benchmark

*KML centroid does not correspond to the named Kampala-metro location.

Figure 1 maps all seventeen candidates at national scale: green Edward/Kyoga villages (main controls), dark grey city checks, open grey Victoria-belt sites dropped from the rural DiD, a star at Kampala, orange CPF/KF, and the black pipeline and feeders.

A.3 Control-pool sensitivity (VIIRS)

All rows use the headline site–month specification (site and year–month fixed effects, SE clustered by site).

Table 9: Split DiD under alternative control pools. `original8`: eight Edward/Kyoga villages (headline). `geo_rural`: adds Bwondha. `noncity`: all candidates except Gulu and Masaka, including Victoria-corridor sites.

Pool	Term	$\hat{\beta}$	SE	p	N ctrl
original8	Fenceline × Post	0.245	0.113	0.042	8
original8	Regional × Post	−0.026	0.041	0.532	8
geo_rural	Fenceline × Post	0.230	0.113	0.054	9
geo_rural	Regional × Post	−0.040	0.041	0.331	9
noncity	Fenceline × Post	−0.019	0.177	0.914	15
noncity	Regional × Post	−0.290	0.142	0.051	15

Leave-one-out on the eight controls keeps the fenceline coefficient between 0.23 and 0.27 and the regional coefficient near zero.

A.4 Fenceline leave-one-out and regional MDE

Table 10 drops each of the nine fenceline towns in turn (headline eight controls) and one specification that drops Kigwera and Buliisa together, the only two settlements within 3 km of the industrial union. The fenceline coefficient stays between 0.169 and 0.297. Dropping Buliisa alone, or Kigwera and Buliisa together, moves the estimate to about 0.17–0.18 with $p \approx 0.09$–0.10: still positive, but no longer significant at 5%. Facility bloom into those nearest polygons would load the lakeshore coefficient; regional towns at 15–40 km sit outside that bleed. From the headline regional SE (0.041), a conventional minimum detectable effect at 5% / 80% power is about 0.11, so the six-town regional arm is powered for radiance shifts on that order, not for effects as small as $|-0.026|$.

Table 10: Fenceline leave-one-out and bloom-pair drop (headline eight controls)

Dropped	$\hat{\beta}_1$	SE	p	N fence
Kigwera	0.267	0.124	0.044	8
Buliisa	0.169	0.094	0.089	8
Kasonga	0.215	0.122	0.094	8
Kyangwali	0.239	0.127	0.073	8
Kagoma	0.262	0.125	0.049	8
Pakwach	0.203	0.118	0.100	8
Karuhinda	0.275	0.122	0.036	8
Nyakageyi	0.275	0.122	0.035	8
Kaiso	0.297	0.113	0.016	8
Kigwera + Buliisa	0.183	0.106	0.098	7

A.5 Robustness regressions (VIIRS)

A.6 Day-of-week patterns (VIIRS)

A.7 Controls time series

A.8 NDVI DiD appendix (full sample 2016–2025)

The primary NDVI estimate restricts to 2019–2025 because early Sentinel-2 years are sparse after cloud filtering. On the full 2016–2025 monthly sample the infrastructure × post-2022 coefficient remains about −0.100 (cluster SE 0.019), close to the primary result, but event-study pre-trends for 2016–2017 are not parallel; those years are therefore kept as appendix only.

Table 11: Split DiD robustness specifications

Spec	Term	$\hat{\beta}$	SE	p
All rural controls (headline sample)				
Site-week	Fenceline × Post	0.250	0.116	0.042
Site-week	Regional × Post	−0.022	0.039	0.571
Site-month + trends	Fenceline × Post	0.257	0.109	0.028
Site-month + trends	Regional × Post	0.006	0.039	0.885
Site-year	Fenceline × Post	0.234	0.112	0.048
Site-year	Regional × Post	−0.024	0.041	0.560
OSRM low-access controls (4 rural sites; N=2,734, 19 clusters)				
Site-month	Fenceline × Post	0.279	0.113	0.023
Site-month	Regional × Post	0.009	0.036	0.806
Site-week	Fenceline × Post	0.285	0.113	0.021
Site-week	Regional × Post	0.013	0.031	0.688

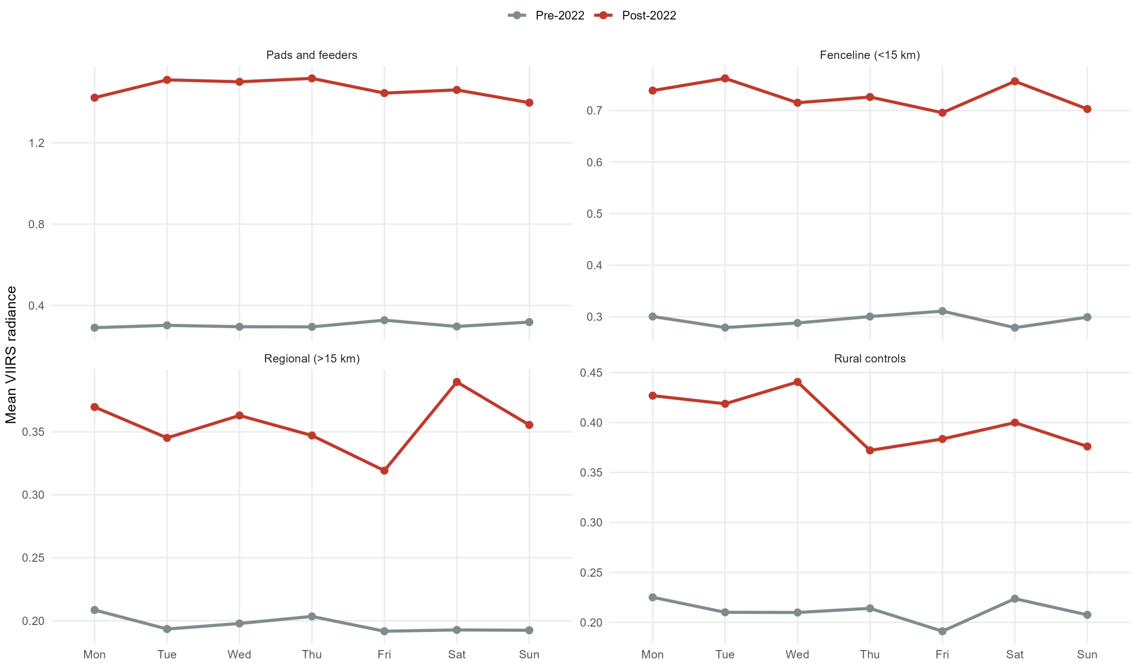


Figure 11: Mean site-day radiance by weekday, pre and post 2022.

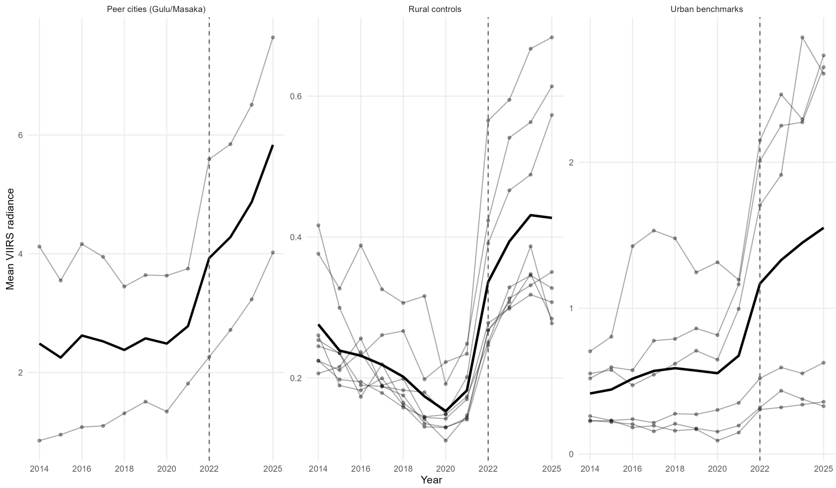


Figure 12: Site-level VIIRS by year: eight Edward/Kyoga rural controls vs. Victoria-corridor and city candidates.

A.9 Supplementary spatial and event-study diagnostics

Among treated pads and feeders, inside versus outside 15 km from the CPF/KF core gives similar post-2022 breaks (−0.101 versus −0.089; only three far sites). The continuous post×distance slope among treated units is essentially zero (0.0004, SE 0.0029, clustered by site to allow for dependence among neighbouring polygons, $p \approx 0.88$; Figure 13). This confirms that pads were cleared wherever they sit across the concession; it is not a test of inland-plain degradation.

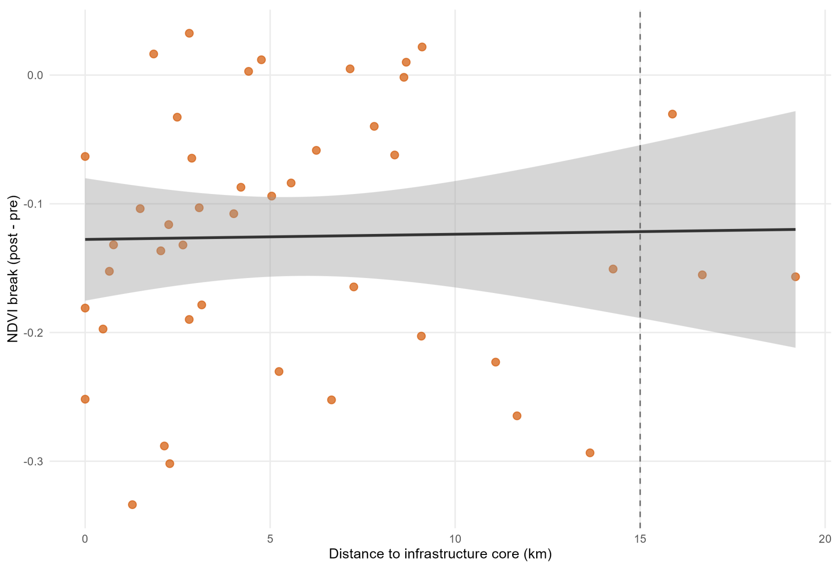
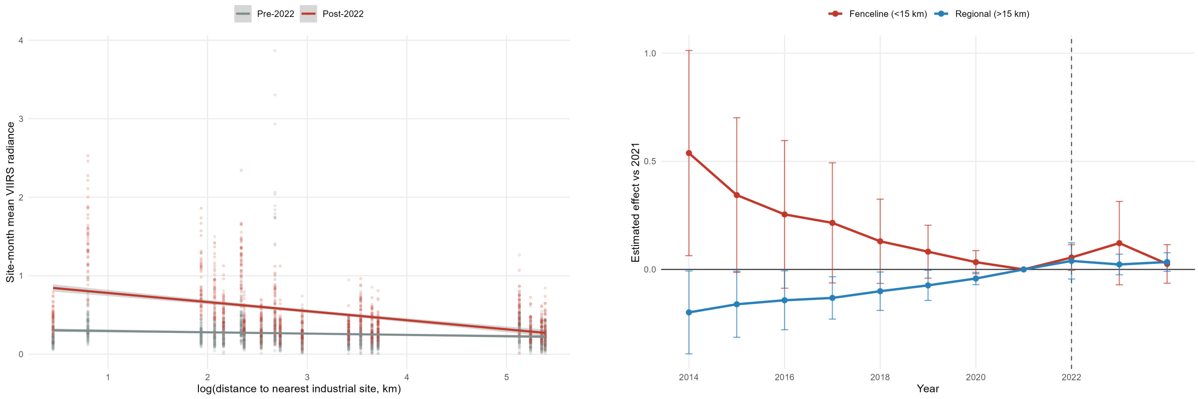


Figure 13: NDVI break (post-2022 minus pre-2022 mean) against distance from the CPF/KF core, by pad/feeder. Dashed line marks the 15 km ring boundary; the flat fitted slope is the null result reported above.

The OSRM subsample shows mean radiance highest near industrial sites after 2022, falling with log distance to nearest infrastructure (Figure 14a). The annual event study with site-specific linear trends using 2021 as the reference year shows wide intervals in early fenceline years, and post-2022 bands cross zero (Figure 14b). The monthly parallel-trends plot (Figure 6) and the headline panel regression (Table 6) remain the primary radiance evidence.



(a) Distance decay

(b) Event study

Figure 14: VIIRS supplementary diagnostics.