Chinese Infrastructure Aid in East Africa and Impact on Development

Master of Chinese Economic and Political Affairs Capstone

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Abstract

This paper examines the economic impact of Chinese-funded road infrastructure projects in five East African countries—Burundi, Kenya, Rwanda, Tanzania, and Uganda—using nighttime light intensity as a proxy for local development. By combining spatial analysis with two-way fixed effects and event study models, the study evaluates whether proximity to newly constructed roads correlate with increased economic activity. Results indicate that road projects have negative effects on district-level nighttime light (NTL) luminosity, with no consistent evidence of broad development gains. These findings suggest that various mechanisms may be detracting from true positive economic impact that could be made with said projects.

Introduction

As China continues to fund infrastructure projects around the world, particularly under the Belt and Road Initiative, there remains a lack of clarity regarding the economic impacts of these developments—especially in regions like East Africa, where transportation infrastructure is vital yet insufficient. While infrastructure has long been a staple of international development aid, the motivations behind such projects appear to be shifting. Increasingly, China's investments in roads, railways, and ports across nearly every continent seem to serve dual purposes: addressing infrastructure deficits in host countries and advancing China's geopolitical and economic influence abroad.

Five East African countries—Burundi, Kenya, Rwanda, Tanzania, and Uganda—offer a compelling context for exploring these dynamics. While Burundi, Rwanda, and Uganda are classified as lower-income countries, Kenya and Tanzania fall into the lower-middle-income bracket. Across the region, one of the most pressing development gaps is access to reliable,

modern infrastructure. Transportation networks, in particular, play a crucial role in economic development by reducing the cost of trade and improving market connectivity. China has invested heavily in the region's infrastructure, especially in Tanzania and Kenya, in order to gain more favorable access to the DR Congo, which is sought after for its intensity in critical mineral resources. China controls 80% of cobalt exports from the DR Congo, which is a critical input for technological products like computers, phones, and EVs, yet the high cost of transporting these resources inland can erode profit margins. It is thus in China's economic interest to improve transport infrastructure, facilitating more efficient access to ports and global markets.

Much of the existing literature on Chinese development aid in Africa focuses on its political implications, such as the strategic alignment of recipient states with Beijing. However, fewer studies rigorously assess the economic development outcomes of these investments. Even fewer examine the impact of infrastructure on the communities, let alone examining roads. Understanding the actual economic effects of Chinese-funded infrastructure, beyond the geopolitical narratives, can help clarify the true intent and value of these projects.

This paper will ask: Do Chinese transportation infrastructure projects, particularly road segments constructed in different East African countries, have a significant measurable positive impact on economic development in recipient communities? If so, how are these benefits spatially distributed as road segments are completed? Finally, do these economic gains accrue evenly across the region, or are some countries or communities disproportionately favored?

Literature Review

Before Belt and Road, China was out in the world making friends via exorbitant infrastructure projects, as well. The Tanzania-Zambia Railway (TAZARA) offered by Mao Zedong to both Tanzania and Zambia in the form of an interest-free loan of one billion renminbi with a 30-year payback period. It was constructed by a Chinese company from 1970 to 1975 and became operational in 1976.[1] This was seen not only as an economic opportunity for China, but also an opportunity to support political interests abroad. At the time, Tanzania and Zambia were both countries with strong Pan-African Socialism movements, and today Tanzania is still considered a socialist country. TAZARA continues to operate as the main railway for products going to EAC and COMESA, but is in disrepair and operates under capacity, making it unprofitable. As a result, soon TAZARA will be conceded to China to operate for a period of 30 years, then will be returned to both Tanzania and Zambia.

After the Angolan Civil War, China had rebuilt much of the infrastructure in the country. Whether this be to back the socialist ruling party, Popular Movement for the Liberation of Angola, or MPLA.[2] China had established a strong presence in Angola and is currently leading the refurbishment of the Benguela Railway in the country[3]—a railroad with much value to the United States for the access it gives into the DR Congo.

The DR Congo is rich with natural resources—particular critical minerals that can be used in the manufacturing of technological products like batteries, semiconductors, and so on. China

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[1] "Our History." TAZARA. Accessed November 25, 2024. https://www.tazarasite.com/our-history.
[2] "Angolan Civil War (1975-2002)." "Burning with a deadly heat": Newshour coverage of the Hot Wars of the Cold War. Accessed November 18, 2024. https://americanarchive.org/exhibits/newshour-cold-war/angola.
[3] Nyabiage, Jevans, and Ralph Jennings. "Could China-US rivalry go off the rails in Africa over a resourceful train route?." South China Morning Post, November 11, 2024. https://www.scmp.com/news/china/diplomacy/article/3285830/chinese-ev-makers-look-africa-rivalry-us-europe-heats?module=perpetual_scroll_1_RM&pgtype=article.

continues to pour money into transportation into these areas to gain access to Central Africa. This leads to a theory that China is seeking to exploit and extract resources from the continent and are funding these projects for China's economic gain.

There is some literature focusing on the use of imported Chinese labor in these projects rather than indigenous labor. Not using local labor makes it so the construction of the project itself has little impact on boosting the local economy. In addition to using Chinese labor, the materials used are also imported from China and funded by loans from China.[4] Many of the economies China is dealing out loans to have high unemployment, but large a large potential working population, so the use of Chinese labor for these development projects is indicative of some level of exploitation.

There is some literature on this, such as Ching Kwan Lee's *Spectre of Global China*, which discusses the difference between Chinese state capital and other capital in development projects. She found that Chinese state capital is driven by profit, geopolitical goals, and resource security, in the end, making the capital act more predatory. As a result, workers tend to be exploited when projects are funded by Chinese state capital.[5] This is not a unique finding, as many Chinese projects are associated with corruption. When examining Chinese aid projects in Tanzania, it was found that all Chinese projects were associated with more experiences of corruption, and even more so when the projects were focused on infrastructure. Inversely, World Bank development projects in Tanzania were not associated with experiences of corruption.[6] China is also different

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[4] Farooq, Muhammad Sabil, Tongkai Yuan, Jiangang Zhu, and Nazia Feroze. 2018. "Kenya and the 21st Century Maritime Silk Road: Implications for China-Africa Relations." *China Quarterly of International Strategic Studies* 4 (3): 401–18. https://doi.org/10.1142/S2377740018500136.

[5] Lee, Ching Kwan. The Specter of Global China: Politics, Labor, and Foreign Investment in Africa. Chicago: University of Chicago Press, 2017.

[6] Brazys, Samuel, Elkink, Johan A., Kelly, Gina. Bad neighbors? How co-located Chinese and World Bank development projects impact local corruption in Tanzania. *Rev Int Organ* **12**, 227–253 (2017). https://doi.org/10.1007/s11558-017-9273-4

from traditional OECD donors, who impose regulations regarding corruption during aid projects.[7]

Despite the experiences with corruption, spending by China increases public support for China in the country receiving the aid by 0.2% in the long run, but 3% in the short run.[8] This has been a net positive in support from African countries for China on the international stage. Grants also increase significantly when a country aligns its UN voting with China, while any financial support decreases by an even greater extent when a country shows recognition for Taiwan.[9]

Banking on Beijing by Austin Strange, Axel Dreher, Andreas Fuchs, Bradley Parks, and Michael J. Tierney explores how China has emerged as the world's largest development financier, operating in ways that differ significantly from traditional donors. Unlike Western aid models, China's "Going Out" policy is commercially driven, emphasizing strategic economic interests. From 2000 to 2012, China loaned an average of $32 billion annually, which surged to $85 billion after the launch of the Belt and Road Initiative (BRI), signaling a shift toward debt-financed development over grants. The book highlights a similar trend: that China tends to favor recipients who offer access to natural resources or markets for Chinese goods and who align with Chinese interests—such as supporting China at the UN and refusing to recognize Taiwan.[10]

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[7] Blair, Robert A., and Philip Roessler. "Foreign Aid and State Legitimacy: Evidence on Chinese and US Aid to Africa from Surveys, Survey Experiments, and Behavioral Games." *World Politics* 73, no. 2 (2021): 315-357. https://dx.doi.org/10.1017/s004388712000026x.

[8] Wellner, Lukas, Axel Dreher, Andreas Fuchs, Bradley Parks, Austin Strange. 2022. "**Can Aid Buy Foreign Public Support? Evidence from Chinese Development Finance**," CEPR Discussion Papers 17128, C.E.P.R. Discussion Papers.

[9] Dreher, Axel, Andreas Fuchs, Brad Parks, Austin M Strange, Michael J Tierney. 2018. "Apples and Dragon Fruits: The Determinants of Aid and Other Forms of State Financing from China to Africa." *International Studies Quarterly* 62 (1): 182–94. https://doi.org/10.1093/isq/sqx052.

[10] Dreher, Axel, Andreas Fuchs, Bradley Parks, Austin Strange, and Michael J. Tierney. "Banking on Beijing: The Aims and Impacts of China's Overseas Development Program". Cambridge: Cambridge University Press, 2022.

While it is inconclusive that these are acts of resource exploitation, it is clear that China gains economically from infrastructure aid projects. It is also a tool for power projection, allowing China to buy votes in the UN and receive more international support. What is unclear is the actual impact these projects will have on recipient communities.

In *The Belt Road and Beyond* by Min Ye, the author presents BRI as a strategic response to China's domestic economic challenges of slowing growth and industrial overcapacity. The concept of "State-Mobilized Globalization," is generated as a model in which the Chinese state actively leverages economic liberalization to advance national interests on the global stage through the creation of transnational economic corridors. In this way, BRI enhances China's energy and trade security while simultaneously expanding its geopolitical influence. Abroad, SOEs play a dominant role in key strategic sectors such as energy and transportation, aligning closely with national priorities and benefiting from greater state support. In contrast, Chinese private firms operate across a broader array of sectors but typically do so with less access to state financing and guidance.[11] The book highlights the strategic nature of BRI to extend China's global reach.

There have been estimates of the impacts, which suggest that Keyan consumers will see the most gains from BRI projects by gaining $380 million, however, the most investments have been made in Ethiopia. Ethiopian consumers were estimated to gain $258 million. Rwandan consumers would gain the least, at only $34 million. At some point, infrastructure investments have diminished marginal returns.[12] The gains to consumers across countries are also

[11] Ye, Min. 2020. The Belt Road and beyond : State-Mobilized Globalization in China: 1998-2018. Cambridge, United Kingdom ; Cambridge University Press.
[12] Mukwaya, Rodgers & Mold, Andrew, 2018. "**Modelling the economic impact of the China Belt and Road Initiative on countries in Eastern Africa**," Conference papers 333014, Purdue University, Center for Global Trade Analysis, Global Trade Analysis Project.

asymmetrical. Gains to consumers do not tell us about the impact on economic development, either, which is generally the goal of development aid. Given this gap, it is vital to understand the actual effects of Chinese infrastructure development projects.

Data

This is an evaluation of the impact of the Chinese-funded road projects on the economic development of level two administrative regions across five different East African countries—that is Burundi, Kenya, Rwanda, Tanzania, and Uganda. Level zero is generally considered the boundaries of the country, then the first division is level one at the sub-national level, which is often states or provinces. Further division is level two, which for most of the selected countries is how granular the sub-national divisions get, and these are generally districts, and will be referred to as districts in this paper. I used various sources of data to first gain an understanding of the spatial relationship between these projects and communities, as well as an econometric approach to understand the economic impact. First, I collected data of country boundaries and administrative regions from the open source GADM, which is a database of global administrative areas. There were in total 816 districts across all five countries. Following this, I used Open Street Maps to map all trunk and primary roads onto each country. A trunk road is a main road used for long distance travel, while primary roads are generally major highways. These types of roads were selected because of the likelihood that they are already paved, although, this was not the case that all of them were prior to the start of the projects. Locations, start dates, and completion dates of Chinese-funded road projects were sourced from AidData at William and Mary, which was then filtered to only include transportation and storage projects, then projects with elements of paving and building roads were selected. Many of the road projects from this

database are poorly geolocated, often using Open Street Maps to show a possible path that could be traveled to move along the roads included in the projects. Projects that had insufficient information to even be located were thrown out. For projects with some viable location data, I used the information on Open Street Maps and cross referenced it with Google Maps to manually map the road projects in QGIS. While some projects were primary and trunk roads, many were also lower tiered roads, such as secondary or tertiary, which are often not used for long distance travel.

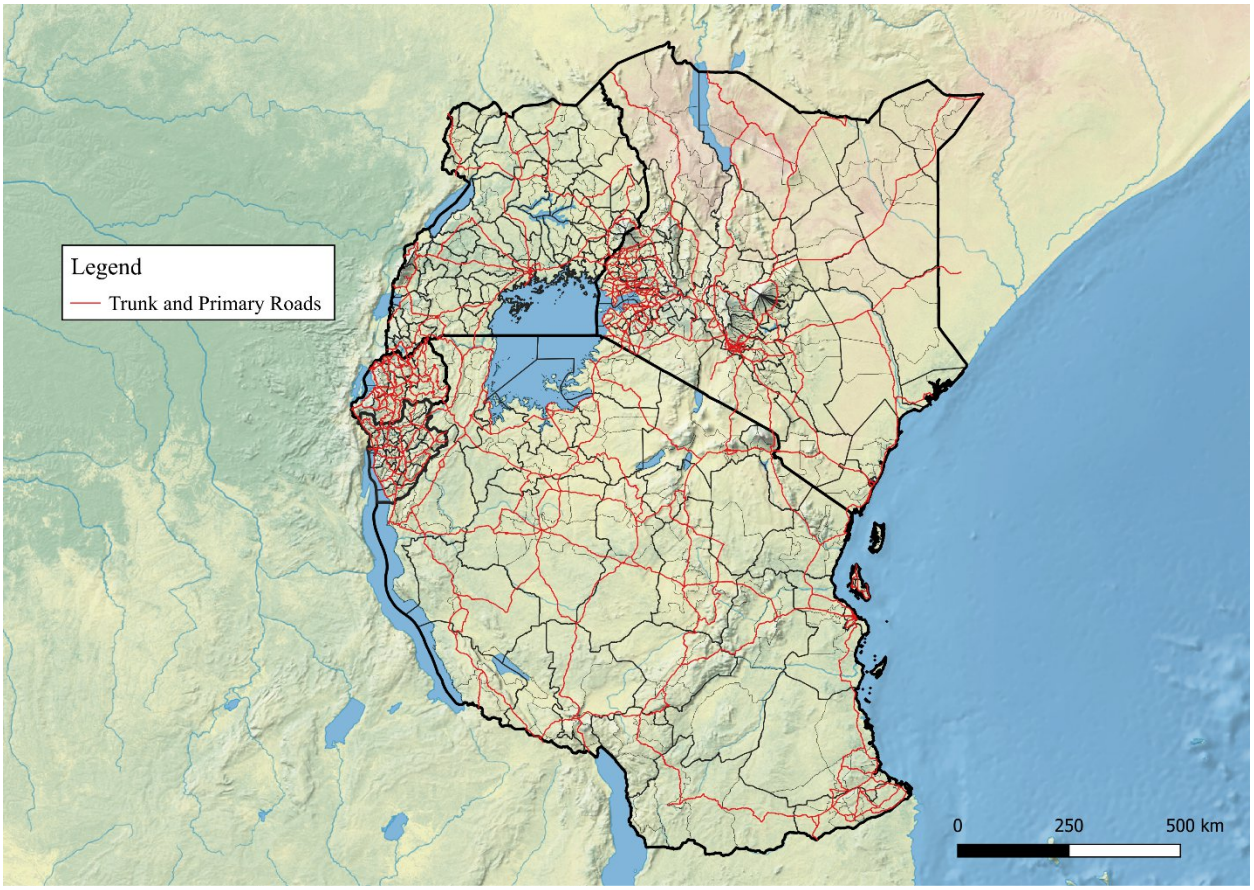

Figure 1: Trunk and Primary Roads Mapped onto East African Countries

Following the mapping of roads, I used QGIS to calculate the centroids of each district. Centroids are the center point of the polygon, in this case the administrative level two region, or

district, which can be used in further calculations. I then took of each centroid from the closest road, prior to projects being included. This was the first distance from the centroid to hub, with the hub being the closest road. Then, the hub distance of each centroid from the closest road including the projects was taken. The change in distance to the closest road, if there was any, derived from this. However, change in distance was not to be taken into account until after the road is built, so a binary variable was created to determine the if the district was treated or not; this was then named "post_treatment."

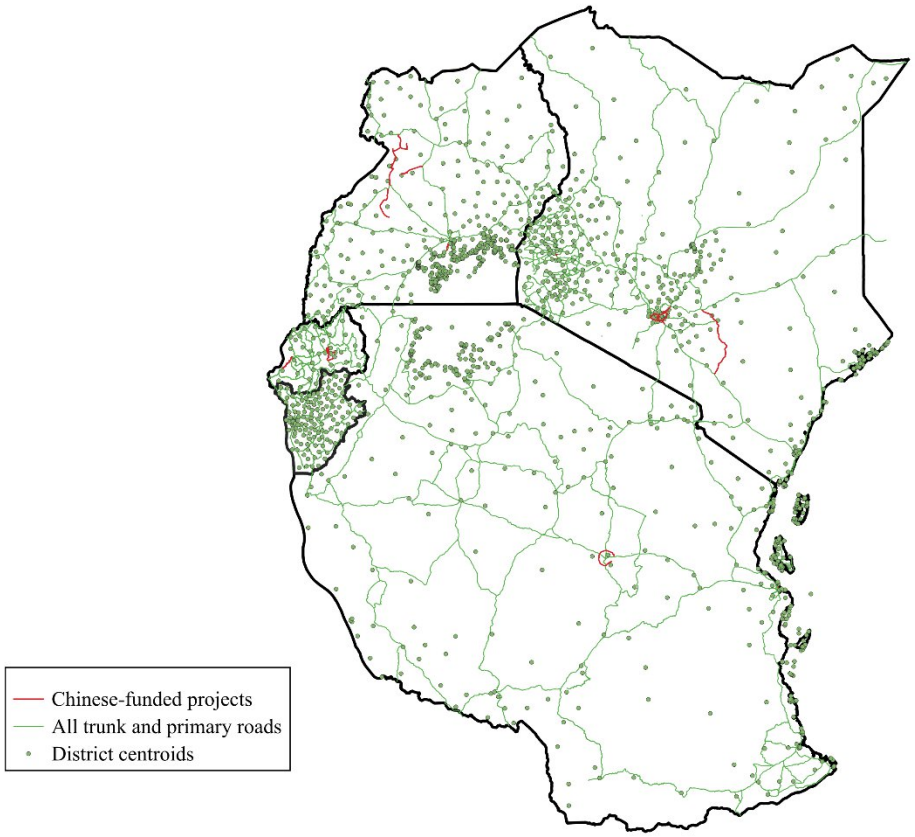

Figure 2: Centroids of Districts Mapped with Chinese-funded Road Infrastructure Projects (Red) and All Other Trunk and Primary Roads (Green)

To measure economic development, nighttime lights are used as a proxy for income levels in the region. Satellite data is sourced from two separate missions, one being the Defense Meteorological Satellite Program Operational Linescan System's (DMSP-OLS) Nighttime Lights Series, which was first launched in 1992 and ended in 2013, and the other being the Visible and Infrared Imaging Suite's (VIIRS) Day/Night Band, which was launched in 2011 and is ongoing. The years 2001 to 2010 were selected from DMSP-OLS, and the years 2011 to 2024 were selected from VIIRS DNB. For each year, the annual mean visual light was selected. The VIIRS mission has significantly improved spatial resolution, sitting at 15 arc second image resolution, while DMSP-OLS has a 30 arc second image resolution. However, the differences in image resolution were mitigated by the use of the district as the unit of analysis. The nighttime lights were then mapped onto the shapefiles of the countries, and the mean luminosity for each district in each year was extracted. For the creation of the maps for this paper, the sensitivity at which to sense light is set at what would be used for sensing rural light. Nighttime light in East Africa is sparce when compared to higher income countries. For this reason, maps may appear dark outside of urban areas. In Figure 3, the brightest lights are present in Dar Es Salaam, Kampala, Nairobi, Mombasa, and Kigali. Bujumbura, Burundi's economic capital, is noticeably dimmer than areas in inland Tanzania, and the political capital of Burundi, Gitega, is barely visible.

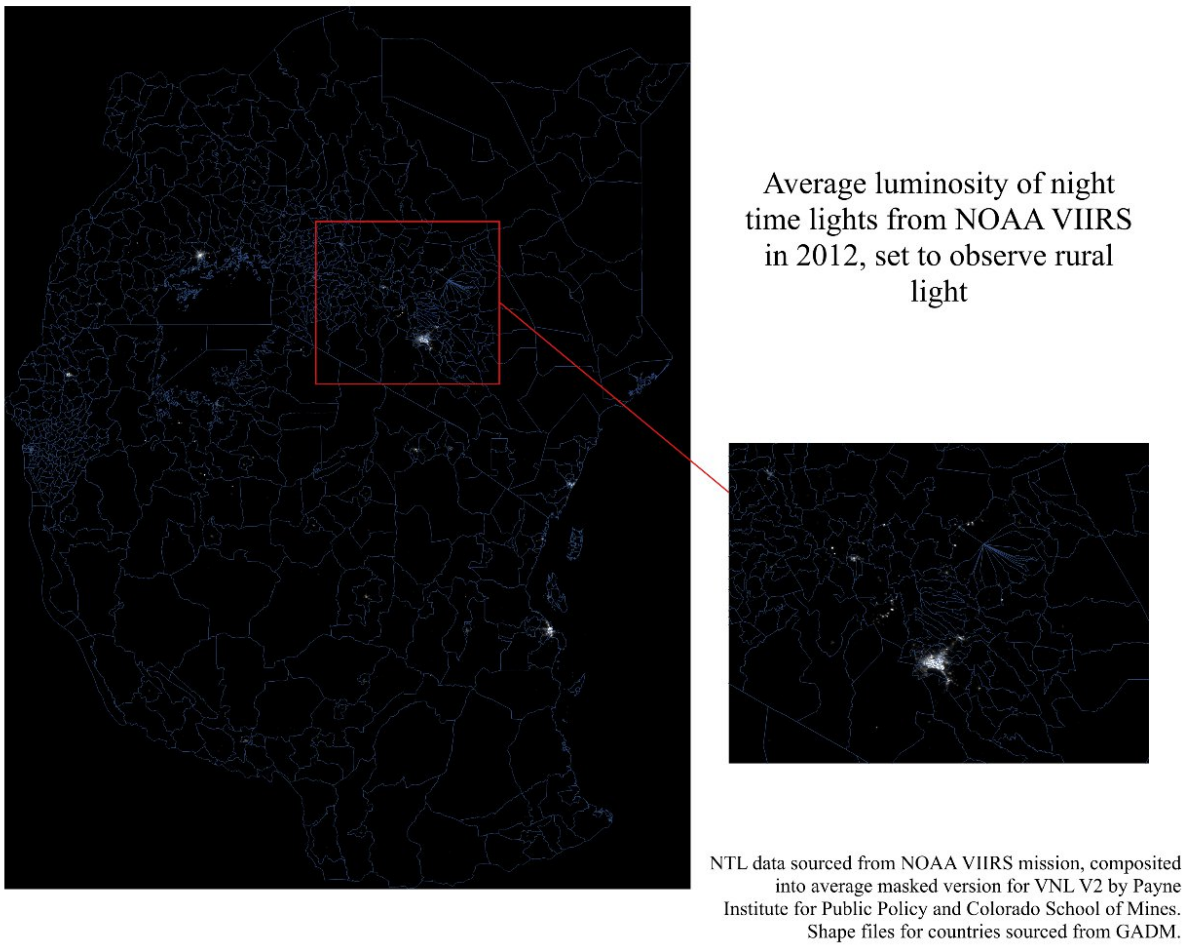

Figure 3: Average Luminosity of Nighttime Lights in 2012

The maximum on the Day/Night Bands for VIIRS are set to 15, again, much lower than what would be considered a high level of luminosity and is used instead for sensing rural light. Although the intensity of light is altered on the map for visualization purposes, this does not affect the levels of luminosity recorded in the dataset.

Following the mapping of the nighttime light (NTL) data onto the shapefiles of the countries and their lower administrative regions, I merged the NTL data with the distance data by district. The NTL data included the average for each district for each year, along with other statistical data, however, I chose to focus on the mean. It should be noted that in countries with unstable energy

infrastructure, such as some of the East African countries this paper is focusing on, the mean can be affected by times when the grid experiences blackouts. These vary greatly for different areas and countries, so blackouts affecting the mean were not considered a concern, as it was considered part of the level of development, as power outages, among other energy issues, can impact economic activity.

Methodology and Design

The use of hub distance from district centroids is also utilized in *On the Road: Access to Transportation Infrastructure and Economic Growth in China* by Banerjee et al but looking at trade between historical Chinese cities and the likelihood of building trainlines connecting them. The methods of that paper use the historical routes as the causal factor on development, but in this paper, historical routes are not estimated. Rather, the relationship between historical routes and roads constructed is inferred, as roads tend to be built along paths that are already used.

There are three separate hypotheses that will be tested:

$$H_1: \textit{Chinese development aid to construct transportation infrastructure in East Africa has a positive economic outcomes on the recipient communities}$$

$$H_2: \textit{The benefits are assymetrical across different communities}$$

$$H_3: \textit{Communities with less developed infrastructure before the development project will see greater economic impact from the project}$$

To test H1 and H2, examining the direct effects of the projects in the surrounding districts will do. However, for H3, it may be necessary to zoom in on specific projects and communities to examine the effects.

A two-way fixed effects model is used for the analysis of data. This is because, first, a difference between a treatment group, districts with projects in closer proximity, and a control group, districts with no change in proximity to a hub, are compared, then, second, the change in mean luminosity over time is being examined.

$$\hat{\delta}_{rd}^{2x2} = \left(x_r^{-post(r)} - x_r^{-pre(r)}\right) - \left(x_d^{-post(d)} - x_d^{-pre(d)}\right)$$

This models the concept of the paper, in which r represents road development, or projects being built that improve access, while d is the economic development, or luminosity of NTL in each district. To put this into a usable format, the following model would be used:

$$y_{it} = \alpha_0 + \delta D_{it} + X_{it} + \alpha_i + \alpha_t + \varepsilon_{it}$$

Here, D represents the "post_treatment" variable created earlier, while X is the change in distance, and y is the average luminosity. Fixed effects for both districts and years are included.

There are a few issues with the data that had to be overcome. Roads are built over time and do not just appear, but as they are being built in segments, they could be used. This becomes an issue in analysis when treatment is gradual. To counteract this, the data is also examined as an event study. To counteract this, two datasets were created: one in which "post_treatment" takes effect after the completion of the road, and one in which "post_treatment" takes effect at the start of construction. The regressions for these two datasets are compared and used to test H1 and H2.

Findings

While there were 816 districts in total, the number of districts receiving projects was highly limited, with only 45 containing any part of a road project. The earliest project starts in 2007 and the latest starts in 2019. The timeline for treatment is as follows:

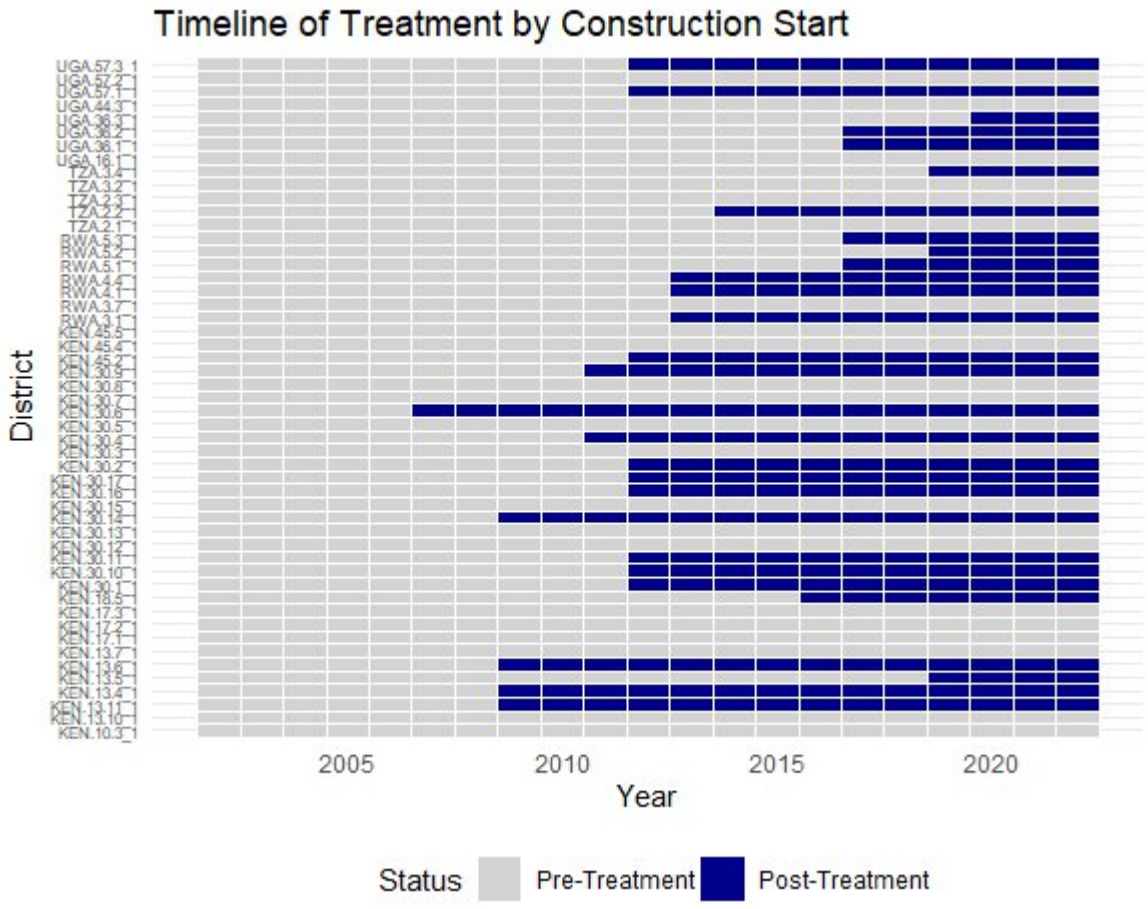

Figure 4: Timeline of Treatment by Construction Start (year of project start is considered time of treatment)

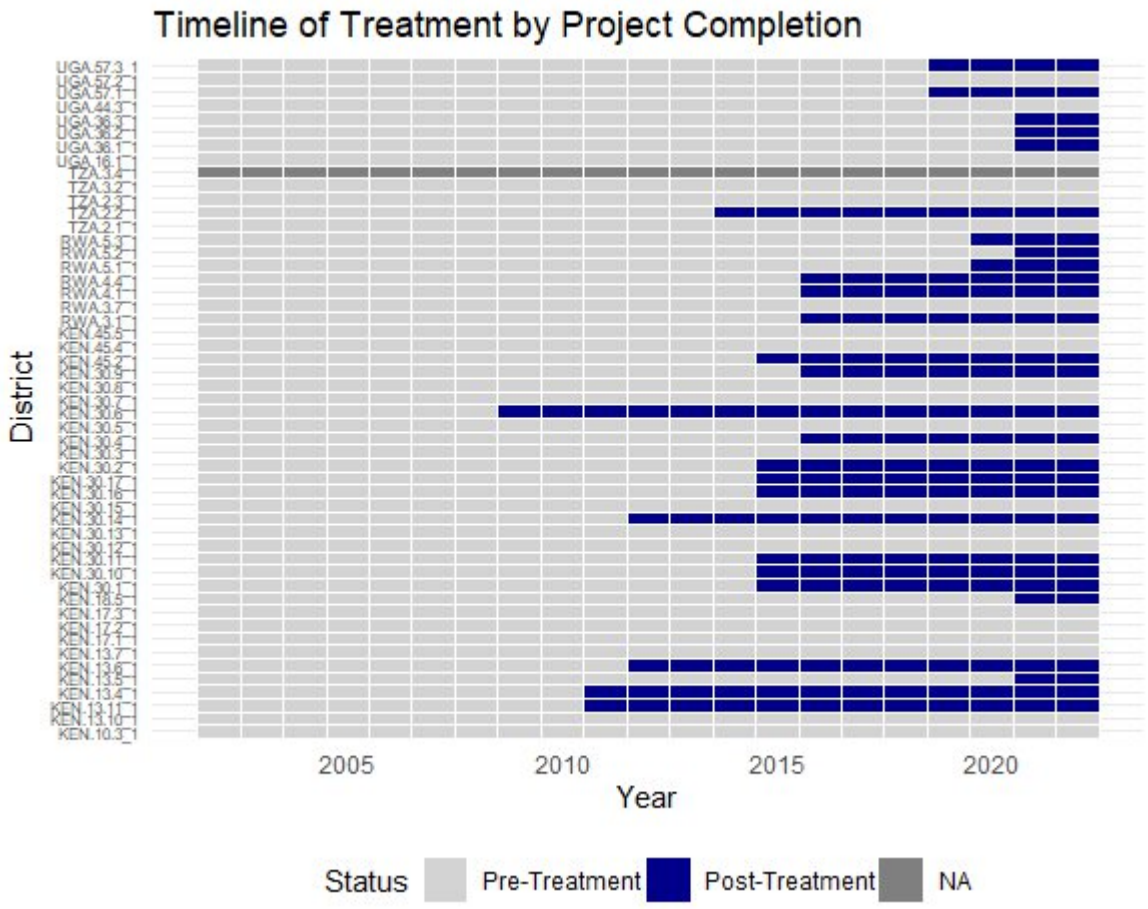

Figure 5: Timeline of Treatment by Project Completion (year of project end is considered time of treatment)

Note that the project in administrative level two region TZA.3.4_1, which is near Dodoma in Tanzania, has a project that is not yet complete, thus the end year for the project is NA. The roads that were not manually coded are missing start and end times, however, these were included in the data and somehow dropped in subsequent filtering. This issue with the data seems to prevail only here, as the other sets of filtered data include appropriate treatment times that were taken into account in the regressions.

The treatment effect is first examined in a two-way fixed effects model, with the district and the year having fixed effects. These results essentially show that the change in distance to a road following the project endpoint, whether it is set at the completion year or the start year, has a

miniscule, and potentially even negative, effect on nighttime light (NTL) luminosity. The results are shown in Table 1. However, the coefficients lack significance. In the two-way fixed-effects model, the results show that “post_treatment”, or the variable used to indicate actual treatment in a given district, has a negative impact of on luminosity with a large magnitude. In the Appendix A, Tables 3 and 4 show the model run with one-way fixed effects, which has nearly no impact on the values for “post_treatment” or the change in distance to a road.

Table 1: Two Way Fixed Effects Results

	After Project Completion	After Project Start
Δ Distance to Road	3.02e-09	7.38e-09
	(4.94e-09)	(1.05e-08)
Post-Treatment	-4.84e+00	-4.15e+00
	(2.24e+00)	(1.92e+00)
Num.Obs.	288912	288912
R2	0.753	0.754
R2 Adj.	0.753	0.753
R2 Within	0.010	0.011
Std.Errors	by: GID_2	by: GID_2
FE: GID_2	X	X
FE: year	X	X

Two-Way Fixed Effects Estimates of Mean Night Time Lights in Each District

The treatment effect is the most important variable to zoom in on here. These coefficients are likely negative to such a great magnitude due to the years of data included before the start of the

projects. These pre-trends bring the impact on luminosity down significantly. Figure 6 presents the coefficient estimates for average NTL luminosity in districts over time with the two-way fixed effects.

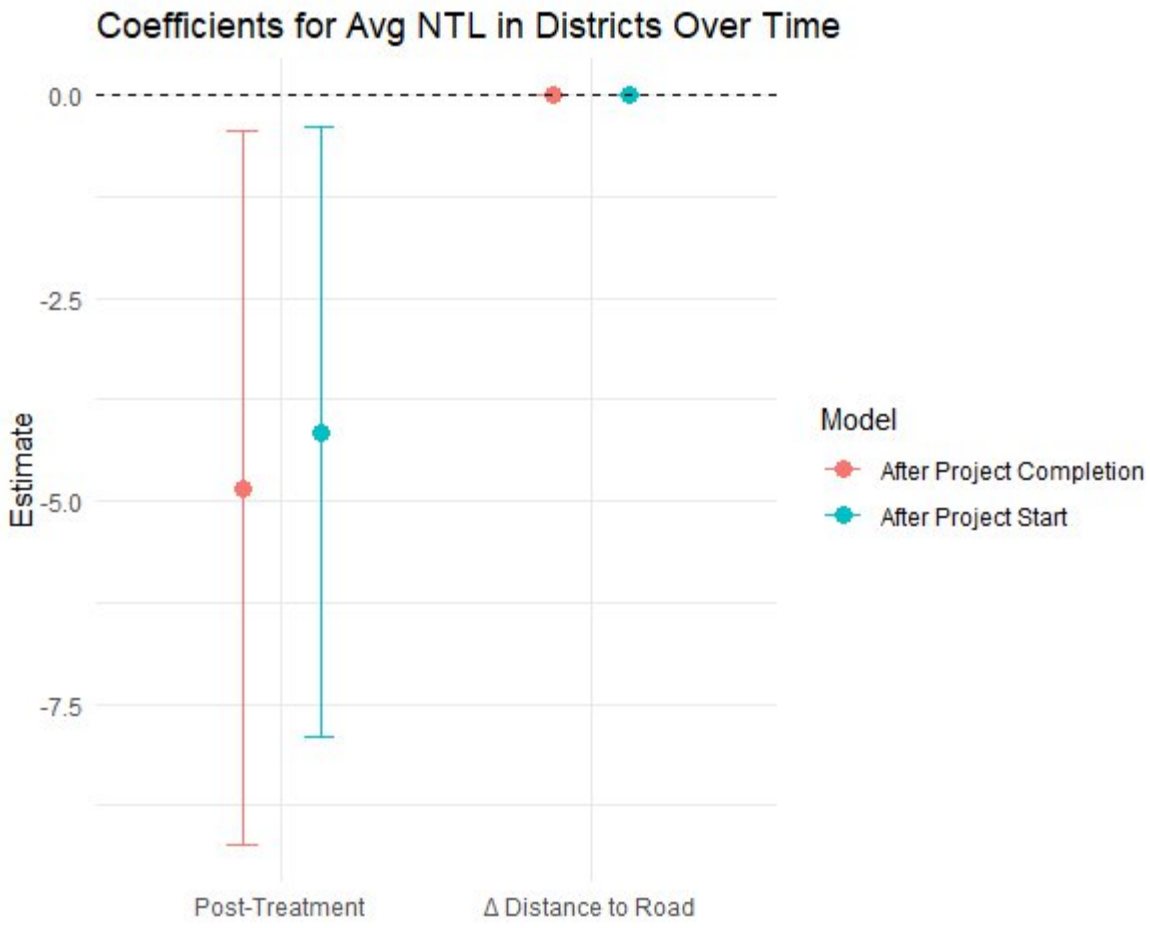

Figure 6: Coefficients for Average Nighttime Lights in Each District Over Time

Another two-way fixed effects model was run filtering for district centroids within five kilometers, which is a reasonable walking distance. These results are presented in Table 2. When filtering for areas that are treated within a certain distance, the impact of the treatment has an even greater adverse effect on economic development. The negative magnitude of this scale

could derive from pre-trends, but it may also indicate a greater issue with the projects, where there is not a positive impact on development as expected.

Table 2: Filtered for Roads within 5km - Two Way Fixed Effects Results

	After Project Completion	After Project Start
Δ Distance to Road	1.69e-21	1.86e-21
	(1.10e-21)	(2.03e-21)
Post-Treatment	-1.38e+01	-1.31e+01
	(3.09e+00)	(3.41e+00)
Num.Obs.	15528	15528
R2	0.775	0.776
R2 Adj.	0.772	0.772
R2 Within	0.033	0.033
Std.Errors	by: GID_2	by: GID_2
FE: GID_2	X	X
FE: year	X	X

Two-Way Fixed Effects Estimates of Mean Night Time Lights in Each District

Discussion

There are some issues in the analysis that limit the scope of the findings. The paths of the roads often follow existing routes. These roads existed prior, but were unpaved, thus these projects are truly paving projects, turning gravel roads into paved ones. The paving of roads dramatically increases efficiency and can still improve trade flow. However, the routes existing prior creates an issue of endogenous treatment. To work within this framework, some robustness checks can be applied. An event study is used to examine the trends over time. Event studies compare placebo pre-treatment leads to the coefficients of the difference-in-difference that is run. Trends would align if the pre-treatment periods have coefficients that are nearly zero, which would suggest that the control and treatment have similar trends pre- and post-treatment. The event study model also uses year and district fixed effects, while looking at the average mean of all districts over time.

While having the ability to work with the staggered introduction of roads, the actual way in which roads are built forces assumptions to be made in the analysis. The completion of the road in the model is represented with a binary variable, but roads do not suddenly appear, they are built over time and may be used while not fully complete. By looking at both the presence of the road at the start year and at the end year, we can compare the difference in the treatment effect in different capacities. The tables below present the event studies for both treatments taking place at the start of construction and the completion of construction.

To check for robustness, and also explore alternative explanations, an event study is used. Figure 8 and Figure 9 show the event study results, which shows average levels of luminosity below the expected returns, while the levels of luminosity reach what is expected around five to ten years prior to completion and remaining stable. This raises the question of whether the roads are lagging development. Many of these places, the towns, cities, and villages, already existed, and

really, we only see road projects that may have the potential to significantly contribute to development in Uganda where it could increase access to mineral and oil resources. This may suggest that the roads being built could improve the flow of traffic, but do not actually improve overall market access for most places. This is reinforced with the concentration of the projects in very few districts, rather than spread out to various places. The trends pre- and post-treatment do not align, but perhaps in an unexpected way.

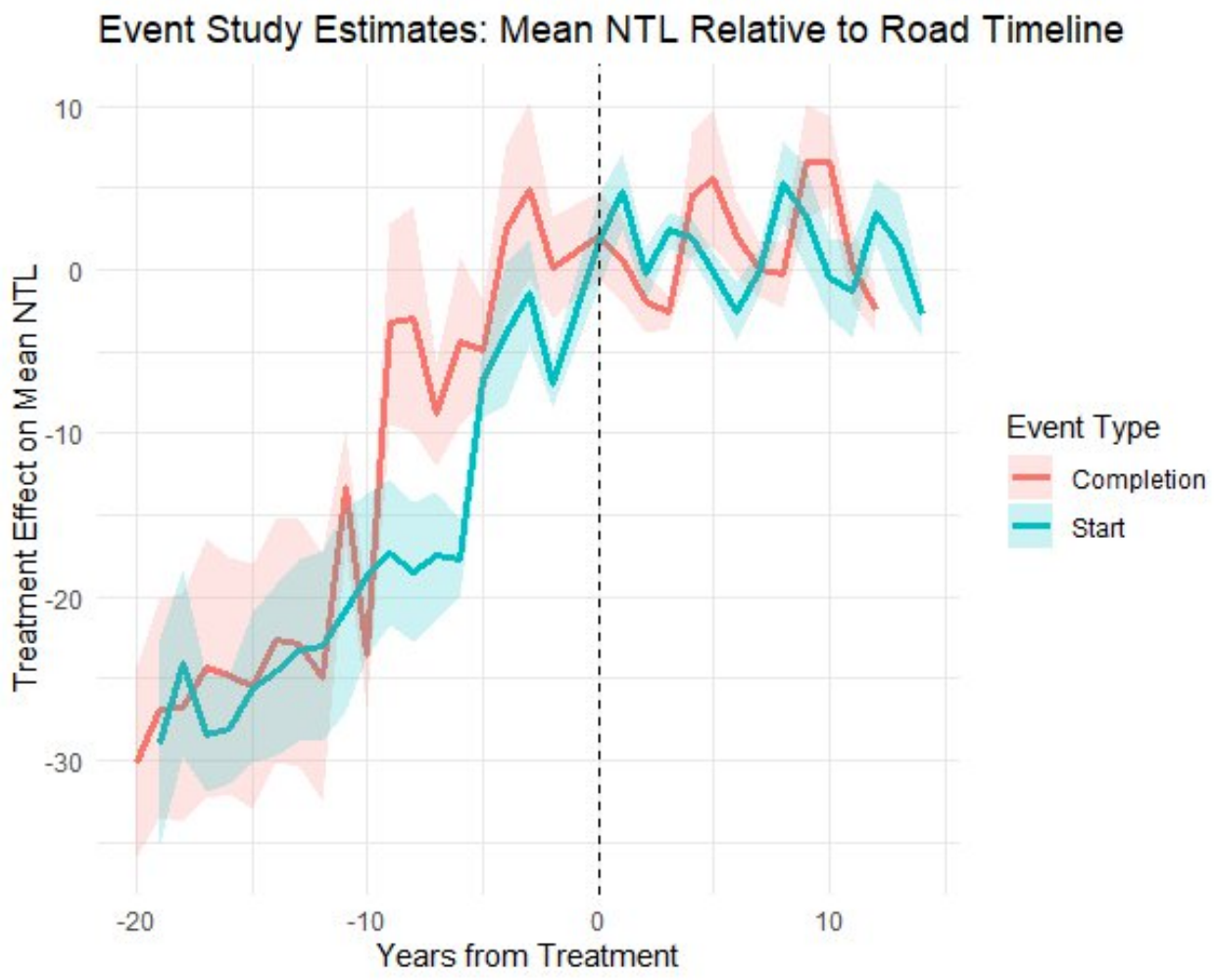

Figure 7: Event Study of Mean Nighttime Lights Relative to Road Timeline

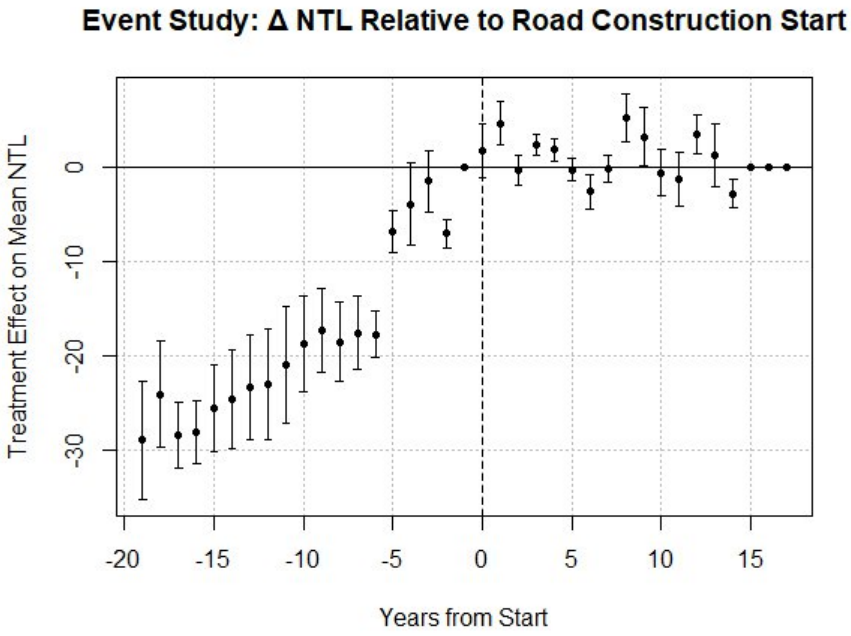

Figure 8: Event Study of Change in Mean of Nighttime Lights Relative to Road Completion Looking at Years from Start of Construction

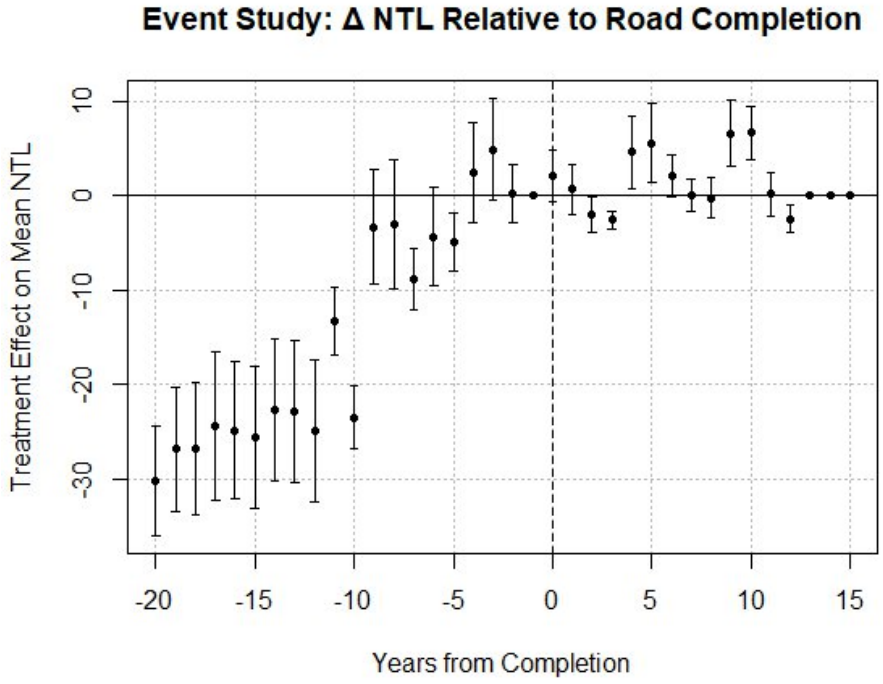

Figure 9: Event Study of Change in Mean of Nighttime Lights Relative to Road Completion Looking at Years from Completion of Construction

In a situation where treatment is endogenous, which can be possible with the roads following already existing paths, turning the road projects into paving projects, parallel trends would be violated. The treatment would be dependent on the outcome and may have changed regardless. But in the case of paving roads, this is the outcome that is expected, as it increases efficiency significantly. Travel on gravel roads can take hours, which can potentially be reduced to mere minutes with paving. The routes that are paved also allow for a greater variety of vehicles and can reduce loss of product in trade that derives from vehicle collisions, overturning, and so on. I am not convinced of the endogeneity of paving roads because while there is an expectation that development may get to a point where the road will be paved, it is not known if the road would be paved in the next year, or within twenty years. There may be an expectation of development that could lead to an increase in economic activity, but knowledge of the actual timeline of development would not be known.

The focus could be pulled to the effect of paving the roads in these regions. This does not give an inherent look into how the mechanism of Chinese funding impacts the uniqueness of the roads and would require further comparison with projects funded by other entities, such as the World Bank. Furthermore, while there may be a negative treatment result, a surface-level reading of this suggesting China is engaging in debt-trap practices to build useless infrastructure in developing countries is not convincing. There are many reasons that building roads may lead to a negative impact on development in these areas. For one, as roads connect smaller towns to cities, people may choose to migrate from the smaller towns and villages to larger cities. Such a choice is economically sound—an increase in access to goods, more employment opportunities, and so on—but it can negatively impact the development of the migrant's place of origin. With more roads being constructed, the movement of goods and services also improves, bringing more

competition along with it. This can also counteract the economic development of a smaller town, as those with monopolies may lose control on prices and other people can seek out goods more easily on their own.

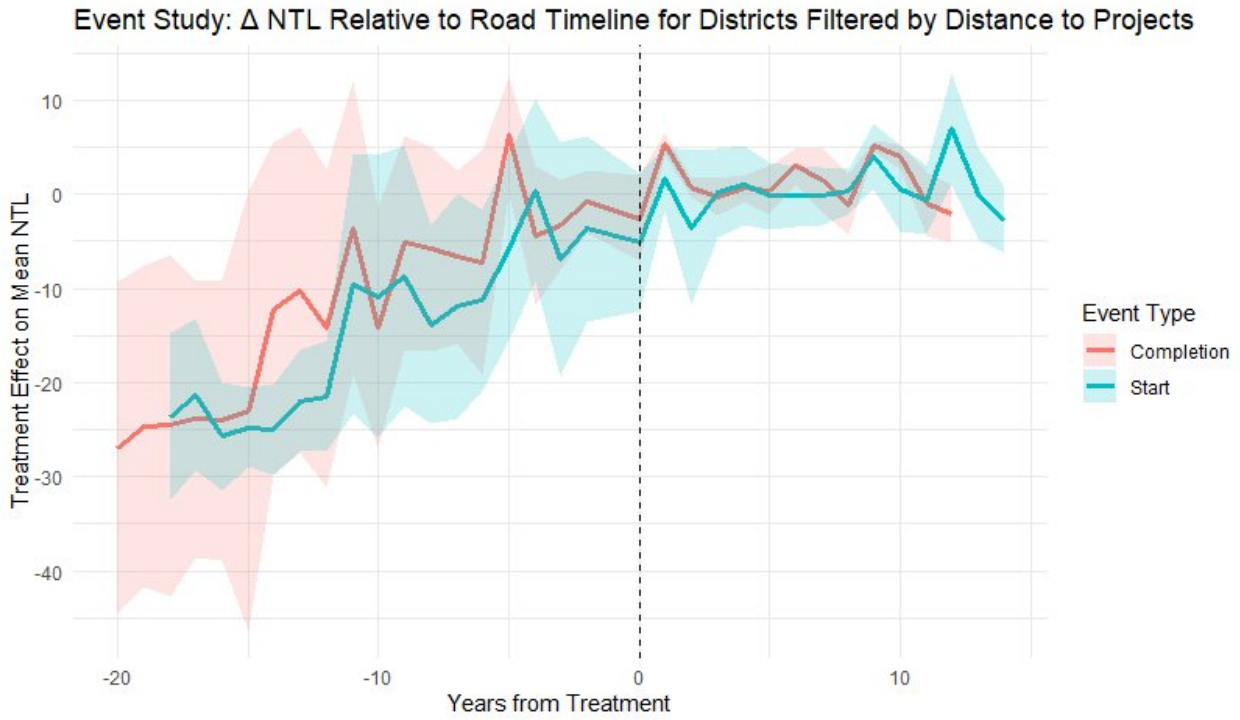

Figure 10: Event Study of Change in Mean NTL Relative to Road Timeline for Districts Filtered by Distance (5km)

Lastly, the dependent variable is the mean luminosity in the districts, which is dependent on other infrastructure, as well. Another question arises with this study, that being whether the action of building the roads itself contributes to an increase in light, then dissipates as construction ends. The construction itself may be attributable to the increase in light, but many of these countries have poor energy infrastructure and are dependent on importing oil. In such a situation, floodlights, either powered by generators or electricity, for construction would be difficult to guarantee the efficacy of, so it is possible that all increase in light is not coming from construction.

Another event study was conducted while filtering for centroids within five kilometers to hubs, or roads, after projects were completed. The model is detailed in Figure 10. This model showed similar results to the first event study, but with greater stability in the trend following treatment. Such a trend reinforces a similar treatment effect to the first event study model.

When looking at the event study with country level fixed effects (Figure 11), we see an opposite effect from the event study with district and year fixed effects, as well as the event study filtering for distance of centroids within five kilometers of a road. Rather, the levels are stable until the time of completion, and then the returns dip below expected levels. Such a trend suggests that when controlling for levels of luminosity across countries, and not the districts, it is at the expected levels until after treatment. The road should have a greater impact on economic development than it is, but the levels are not meeting what is expected. District fixed effects were showing a possible effect of roads increasing competition and access to movement, pulling resources, both human and material, away from smaller communities. However, at the country level, there is less of a focus on individual communities. What could be contributing to this trend is that many of the districts receiving projects are already in urban areas, meaning that despite the treatment, levels are still dipping. The infrastructure is not having a noticeable positive impact, which can be an issue, considerable due to the fact that infrastructure projects should be funded with a goal in mind. While some of these projects included feasibility studies prior to construction, the impact on communities and development may not have been a primary consideration in choosing to fund and construct this infrastructure. Rather, it seems infrastructure that was desired by the recipient country was built, whether it could be useful in a considerable capacity immediately or not.

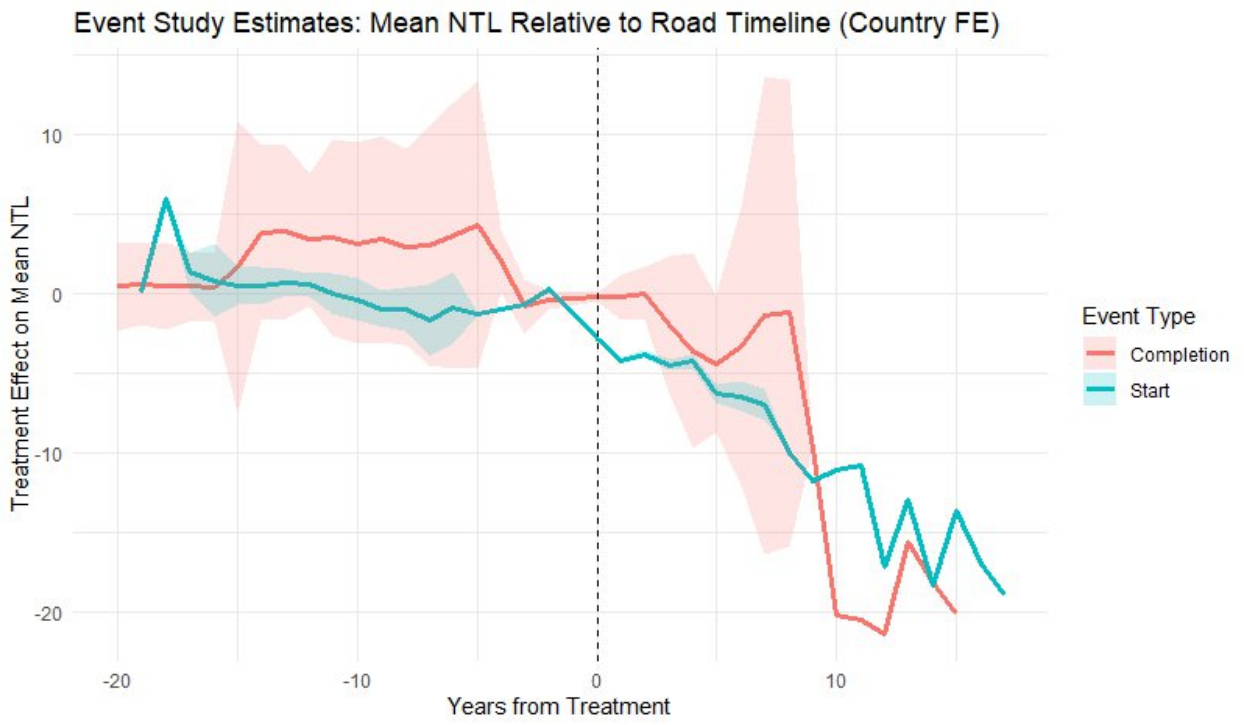

Figure 11: Event Study of Change in Mean NTL Relative to Road Timeline with Country Fixed Effects

Conclusion and Implications

This study set out to evaluate the local economic effects of Chinese-funded road infrastructure projects across five East African countries—Burundi, Kenya, Rwanda, Tanzania, and Uganda—using nighttime light intensity as a proxy for economic activity. Despite common assumptions that large-scale transportation investments spur development, the empirical evidence presented here reveals a more nuanced and often underwhelming outcome. For the first hypothesis (H1) that Chinese development aid to construct transportation infrastructure in East Africa would have positive economic outcomes in the recipient communities, this was not the case according to all the models used in the paper. The second hypothesis (H2) that benefits are asymmetrical across different communities, we do not see tangible economic benefits, however, we do see some level

of impact, though negative. This did accrue asymmetrically across communities, as seen in the models filtering for centroids within five kilometers. The impact, with trends included, was to a greater negative effect than when including all centroids despite distance to a road following the completion of projects. The third hypothesis (H3), that communities with less developed infrastructure before the development project will see greater economic impact was left open, as the majority of the projects were concentrated in already urbanized areas. To further test this hypothesis, it would be necessary to zoom into specific locations and examine the impacts separately as case studies. Regardless, across multiple model specifications, including two-way fixed effects and event study frameworks, the estimated treatment effects of road completion were negative to a significant degree. These findings do not suggest that in the aggregate Chinese-financed road projects in these contexts have not led to immediate or measurable gains in local economic development, rather that there may be other impacts from building roads. To further measure the impact between Chinese-financed roads and roads financed by other organizations, investigation into projects built by World Bank or any entities, then a comparison with the subsequent economic development in areas with Chinese-funded projects would be necessary. Though beyond the scope of this paper, this is important for consideration, as well.

The results can possibly be explained by several factors. First, many projects followed existing road alignments, often upgrading unpaved routes. While paving can enhance transportation efficiency, the economic effects of such improvements may be modest, especially if they serve areas already integrated into broader markets. Second, the concentrated nature of these investments that limited them to a small subset of districts reduces the potential for spatial spillovers. Third, new roads may contribute to rural-urban migration and increased competition in local markets, possibly disadvantaging smaller or less prepared communities. Fourth, the lack

of local labor use and imported materials in many Chinese projects may minimize immediate economic spillovers within host communities.

Concurrently, there are several important implications for development strategy, policy, and future research. First, Chinese funded projects are often backing riskier investments that other entities will not undertake. Despite this, infrastructure projects should be preceded not only by feasibility assessments, but also of economic potential and long-term usage patterns. Simply paving roads will not necessarily automatically stimulate development if they do not meaningfully reduce barriers to market access or production. In this way, feasibility for a project should evaluate economic outcomes of the investment, improving its quality. Second, roads may not lead to growth unless they are paired with other infrastructure, such as appropriate energy infrastructure. Local economic gains depend on whether firms can utilize the new transport linkages efficiently. Third, the results reinforce concerns that China's overseas infrastructure investments under BRI may prioritize geopolitical or resource access goals over measurable development outcomes. While strategic interests are a legitimate part of foreign policy, conflating development aid with geopolitical leverage may weaken long-term sustainability and accountability. Fourth, while nighttime lights are a powerful proxy for economic activity, they may miss more localized or sector-specific effects, especially in agrarian or energy-poor settings. Future studies could benefit from combining NTL data with other economic data, if available, to provide a clearer picture of infrastructure impacts. Lastly, further studies should not only seek to improve the economic data available but work to circumvent other issues found within the data leading to null results in this paper. Measuring the progress of road construction over time and examining how this trends with NTL could be more impactful.

While the results are not a satisfying answer to all the questions initially posed, this paper suggests that these infrastructure projects overall are not having a positive impact on economic development when examining across administrative level two regions. Ultimately, roads are essential, but not the end-all of development. Rather, development is complex and improves when a system of factors is improved. There is no point in building a road to nowhere. But it is not an indication of inherently predatory practices on China's part, possibly rather China putting a greater emphasis on the geopolitical gains that can come from providing aid. The onus may be on China to improve the mechanisms surrounding their investments, including better analysis of the effects on the recipient communities, but at the very least, China is funding projects that may otherwise be rejected.

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Appendix A: Tables and Figures

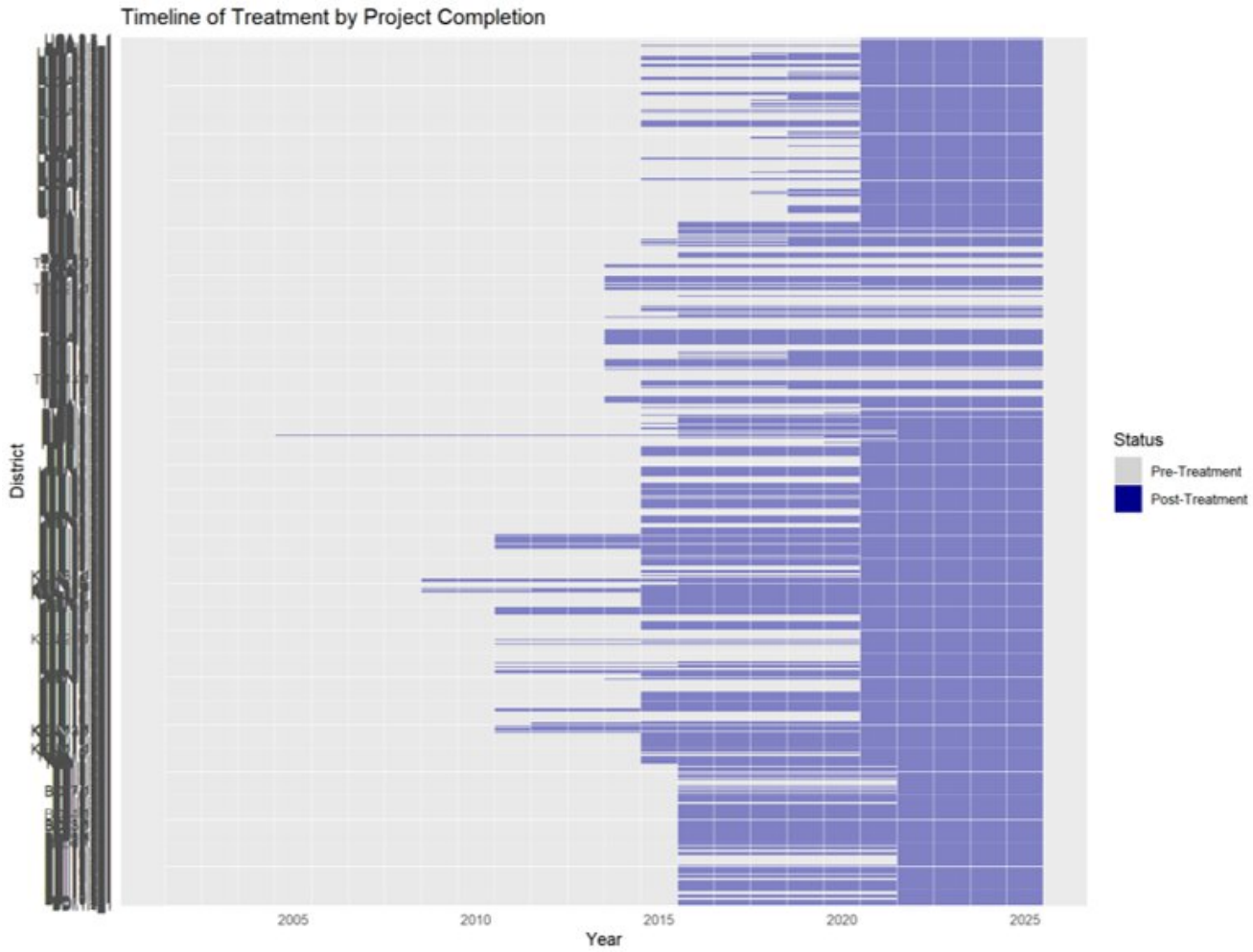

Figure 12: Timeline of Treatment

Table 3: Year Fixed Effects Model

	After Project Completion	After Project Start
Δ Distance to Road	3.02e-09	7.38e-09
	(1.93e-09)	(2.32e-09)
Post-Treatment	-4.84e+00	-4.15e+00
	(1.37e+00)	(7.43e-01)
Num.Obs.	288912	288912
R2	0.753	0.754
R2 Adj.	0.753	0.753
R2 Within	0.752	0.752
Std.Errors	by: year	by: year
FE: year	X	X

Year Fixed Effects Estimates of Mean Night Time Lights in Each District

Table 4: District Fixed Effects Model

	After Project Completion	After Project Start
Δ Distance to Road	3.02e-09	7.38e-09
	(4.94e-09)	(1.05e-08)
Post-Treatment	-4.84e+00	-4.15e+00
	(2.24e+00)	(1.92e+00)
Year: 2002	-1.48e-01	-1.48e-01
	(1.04e-01)	(1.04e-01)
Year: 2003	-2.14e-01	-2.14e-01
	(1.43e-01)	(1.43e-01)
Year: 2004	-1.62e-01	-1.62e-01
	(9.72e-02)	(9.72e-02)
Year: 2005	-1.85e-01	-1.85e-01
	(1.14e-01)	(1.14e-01)
Year: 2006	-1.69e-01	-1.69e-01
	(1.16e-01)	(1.16e-01)
Year: 2007	-1.25e-01	-1.25e-01
	(9.82e-02)	(9.82e-02)
Year: 2008	-1.15e-01	-1.14e-01
	(9.16e-02)	(9.15e-02)
Year: 2009	-1.12e-01	-1.11e-01
	(9.27e-02)	(9.26e-02)
Year: 2010	1.11e-01	1.12e-01
	(5.09e-02)	(5.12e-02)
Year: 2011	7.02e-02	7.10e-02
	(3.96e-02)	(3.99e-02)
Year: 2012	-4.78e-01	-4.77e-01
	(2.58e-01)	(2.58e-01)
Year: 2013	-4.62e-01	-4.60e-01
	(2.51e-01)	(2.50e-01)
Year: 2014	-4.57e-01	-4.51e-01
Year: 2015	4.53e-01	4.47e-01
	(2.48e-01)	(2.46e-01)
Year: 2016	-4.47e-01	-4.43e-01
	(2.45e-01)	(2.44e-01)
Year: 2017	-4.24e-01	-4.24e-01
	(2.37e-01)	(2.37e-01)
Year: 2018	-4.19e-01	-4.14e-01
	(2.34e-01)	(2.33e-01)
Year: 2019	-3.91e-01	-3.83e-01
	(2.19e-01)	(2.17e-01)
Year: 2020	-3.95e-01	-3.87e-01
	(2.20e-01)	(2.18e-01)
Year: 2021	-3.81e-01	-3.73e-01
	(2.17e-01)	(2.16e-01)
Year: 2022	-3.31e-01	-3.34e-01
	(1.93e-01)	(1.94e-01)
Year: 2023	-2.82e-01	-2.85e-01
	(1.69e-01)	(1.70e-01)
Year: 2024	4.56e+00	3.87e+00
	(2.25e+00)	(1.93e+00)
Num.Obs.	288912	288912
R2	0.753	0.754
R2 Adj.	0.753	0.753
R2 Within	0.030	0.030
Std.Errors	by: GID_2	by: GID_2
FE: GID_2	X	X

District Fixed Effects Estimates of Mean Night Time Lights in Each District

Regression of Treatment with Year and District Trends	
(Intercept)	1.04e+01***
	(1.88e+00)
factor(is_treated)1	-6.27e+00***
	(9.60e-01)
factor(GID_2)KEN.13.4_1	-1.85e+00
	(2.01e+00)
factor(GID_2)KEN.13.5_1	1.25e+00
	(2.05e+00)
factor(GID_2)KEN.18.1_1	-7.20e+00***
	(2.05e+00)
factor(GID_2)KEN.18.2_1	-7.46e+00***
	(2.05e+00)
factor(GID_2)KEN.18.3_1	-7.44e+00***
	(2.05e+00)
factor(GID_2)KEN.18.4_1	-7.46e+00***
	(2.05e+00)
factor(GID_2)KEN.30.1_1	3.04e+01***
	(2.02e+00)
factor(GID_2)KEN.30.10_1	3.08e+01***
	(2.02e+00)
factor(GID_2)KEN.30.11_1	5.09e+00*
	(2.02e+00)
factor(GID_2)KEN.30.12_1	3.82e+01***
	(2.01e+00)
factor(GID_2)KEN.30.14_1	1.62e+01***
	(2.01e+00)
factor(GID_2)KEN.30.17_1	2.06e+01***
	(2.02e+00)
factor(GID_2)KEN.30.2_1	1.34e+01***
	(2.02e+00)
factor(GID_2)KEN.30.3_1	2.82e+01***
	(2.02e+00)
factor(GID_2)KEN.30.5_1	3.05e+01***
	(2.02e+00)
factor(GID_2)KEN.30.7_1	3.56e+01***
	(2.01e+00)
factor(GID_2)KEN.30.8_1	3.50e+01***
	(2.01e+00)
factor(GID_2)KEN.30.9_1	2.42e+00
	(2.02e+00)
factor(GID_2)KEN.30.9_1	2.42e+00
	(2.02e+00)
factor(GID_2)RWA.3.7_1	-5.79e+00***
	(1.75e+00)
factor(GID_2)RWA.5.1_1	-2.34e+00
	(1.76e+00)
factor(GID_2)TZA.3.2_1	-8.54e+00***
	(2.09e+00)
factor(GID_2)TZA.3.4_1	-7.94e+00***
	(2.09e+00)
factor(GID_2)UGA.24.1_1	-7.45e+00***
	(2.05e+00)
factor(GID_2)UGA.24.3_1	-7.46e+00***
	(2.05e+00)
factor(GID_2)UGA.36.1_1	-7.45e+00***
	(2.05e+00)
factor(GID_2)UGA.36.2_1	-7.43e+00***
	(2.05e+00)
factor(GID_2)UGA.36.3_1	-7.43e+00***
	(2.05e+00)
factor(GID_2)UGA.9.1_1	-7.38e+00***
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factor(year)2006	8.34e-01
	(1.73e+00)
factor(year)2007	1.55e+00
	(1.73e+00)
factor(year)2008	1.48e+00
	(1.73e+00)
factor(year)2009	3.52e+00*
	(1.73e+00)
factor(year)2010	5.82e+00***
	(1.73e+00)
factor(year)2011	5.23e+00**
	(1.74e+00)
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	(1.74e+00)
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	(1.74e+00)
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	(1.81e+00)
factor(year)2017	-4.53e+00*
	(1.81e+00)
factor(year)2018	-5.50e+00**
	(1.81e+00)
factor(year)2019	-3.59e+00*
	(1.81e+00)
factor(year)2020	-4.27e+00*
	(1.82e+00)
factor(year)2021	-2.48e+00
	(1.95e+00)
factor(year)2022	-2.10e-01
	(1.95e+00)
factor(year)2023	1.43e+00
	(1.95e+00)
factor(year)2024	1.49e+00
	(1.95e+00)
Num.Obs.	713
R2	0.861
R2 Adj.	0.850
RMSE	6.56

+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001

Regression Estimates of Mean Night Time Lights in Each District

Table 5: Regression of Treatment with Year and District Trends

Appendix B: Maps

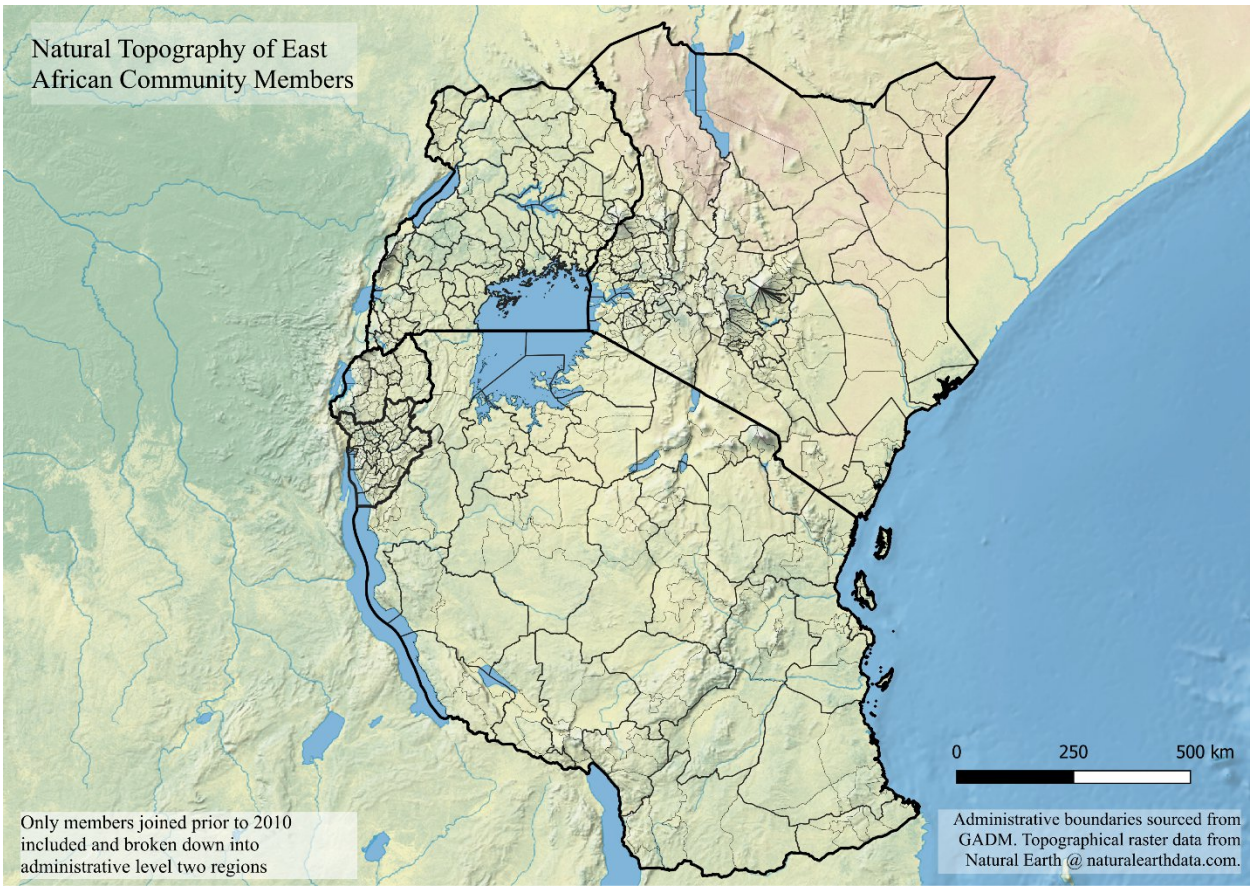

Figure 13: Natural Topography of East Africa

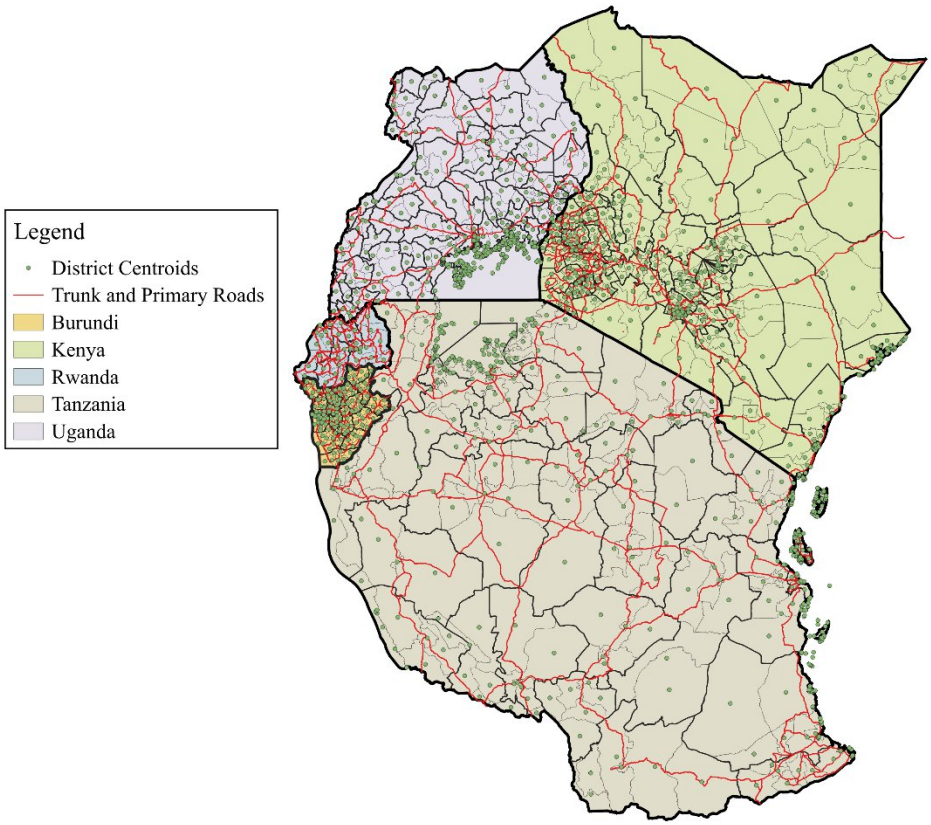

Figure 14: Locations of District Centroids in Relation to Trunk and Primary Roads Across Level 2 Administrative Regions

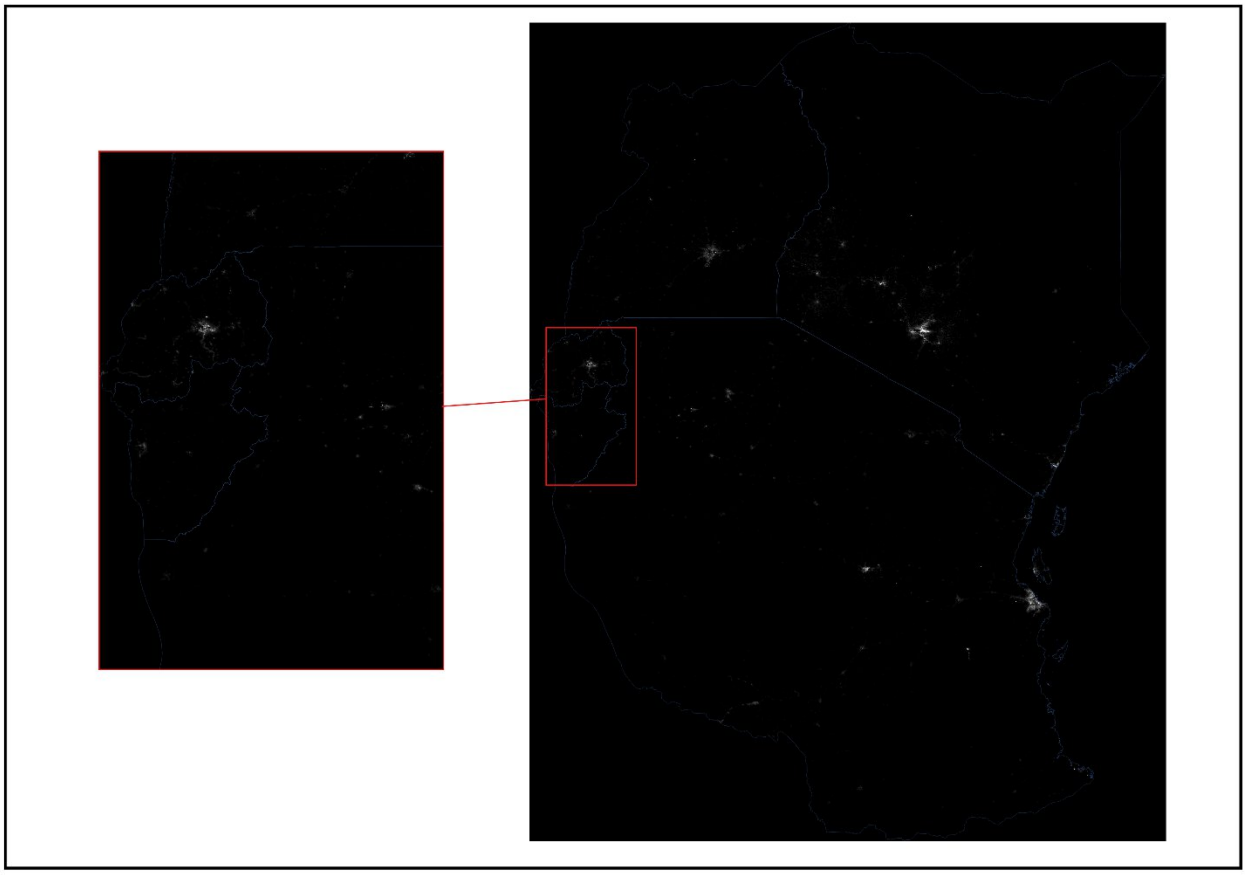

Figure 15: Difference in NTL Average Luminosity between 2021 and 2013 in East Africa

Figure 16: 2013 NTL in East Africa

Figure 17: 2014 NTL in East Africa

Figure 18: 2015 NTL in East Africa

Figure 19: 2016 NTL in East Africa

Figure 20: 2017 NTL in East Africa

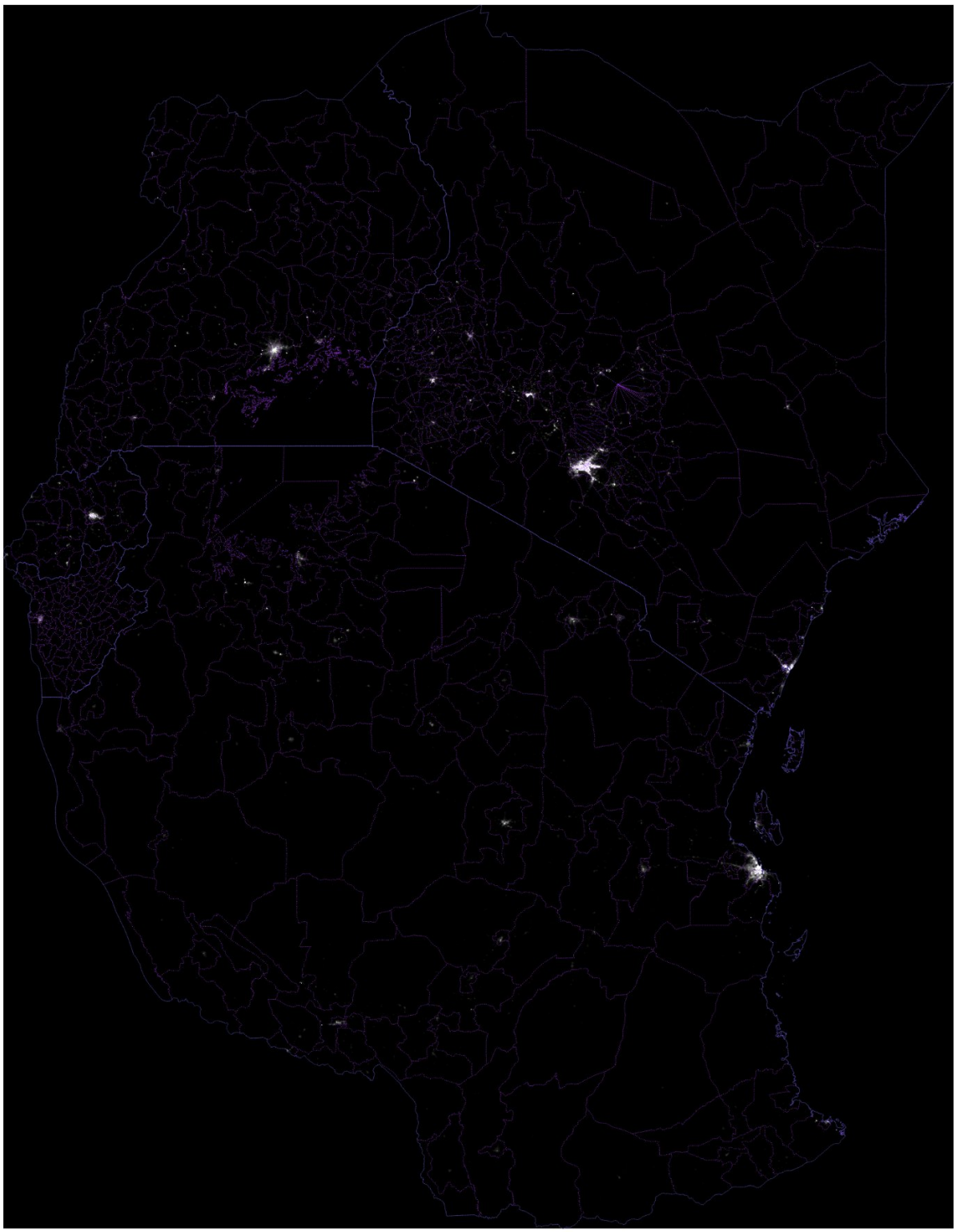

Figure 21: 2018 NTL in East Africa

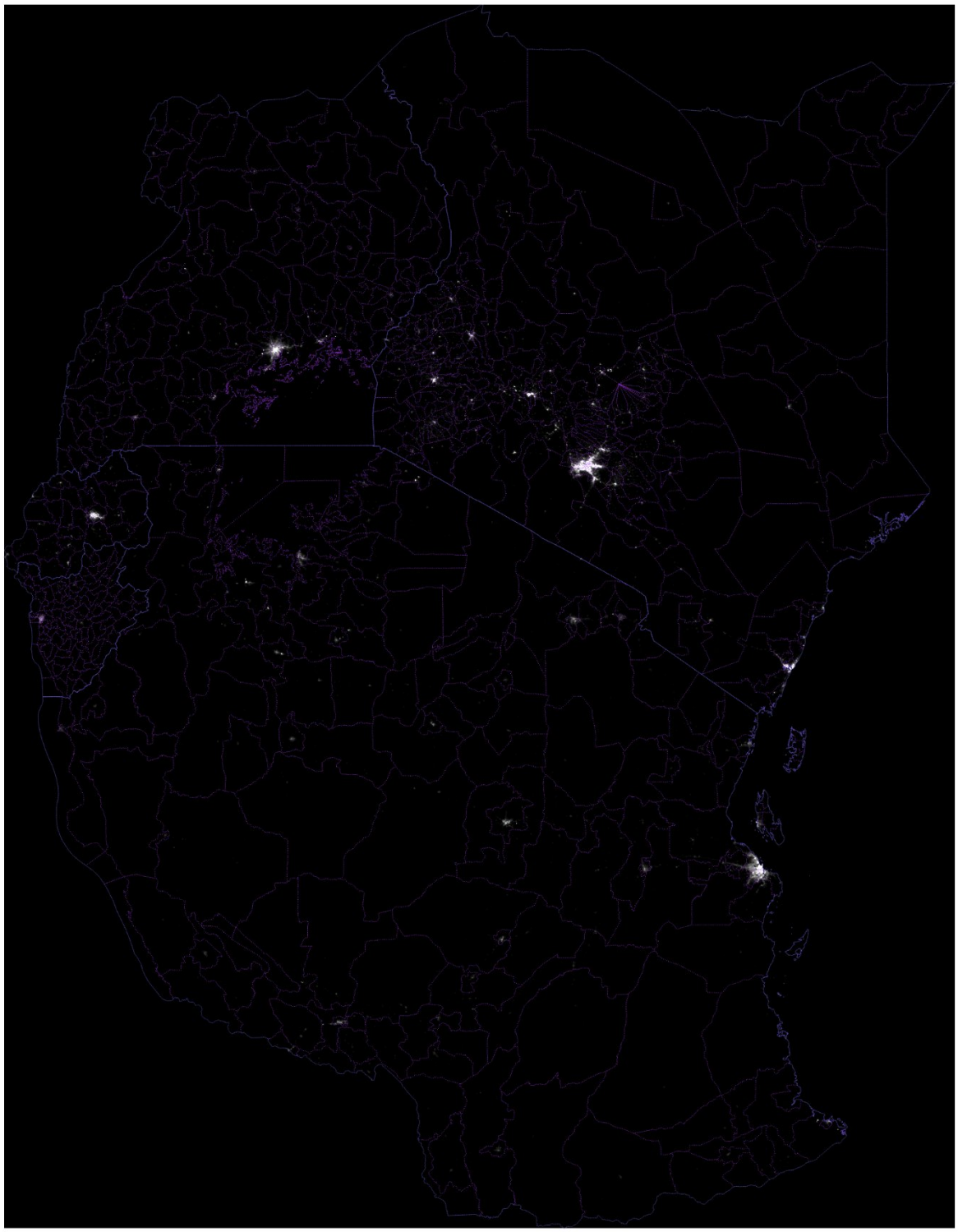

Figure 22: 2019 NTL in East Africa

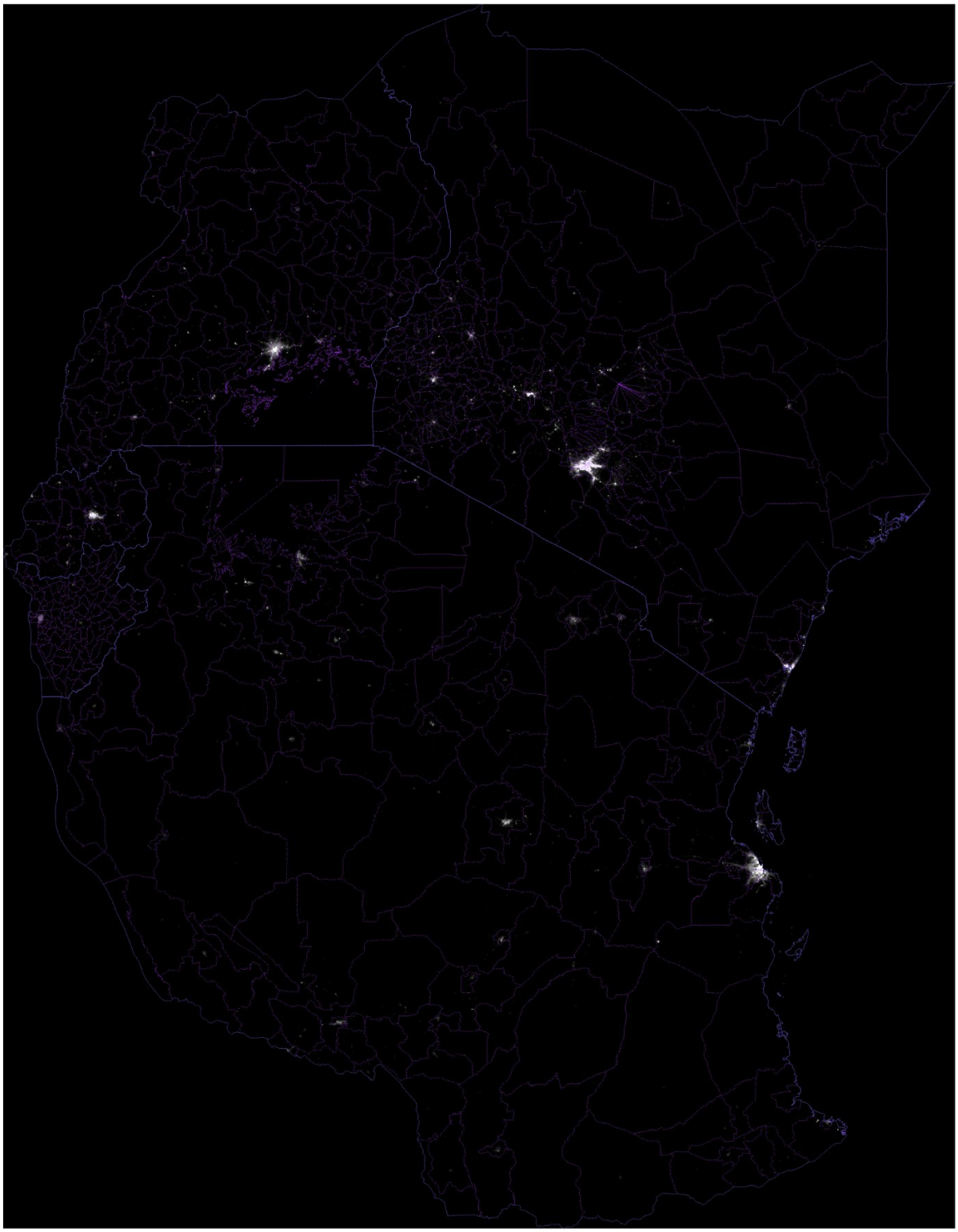

Figure 23: 2020 NTL in East Africa

Figure 24: 2021 NTL in East Africa