International Labour Organization

ILO brief

Research Brief

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Harnessing nighttime lights data to measure the economic and employment effects of road infrastructure in sub-Saharan Africa

Introduction

Assessing economic growth and employment is key for measuring progress towards SDG8, aiming to promote the creation of sustainable economic growth, full and productive employment and inclusive decent work. For countries for which there is scarcity of traditional data sources and indicators, particularly at the local level, remotely sensed satellite imagery in the form of nighttime lights (NTL) can be utilized to assess changes in economic outcomes, which can be translated into employment. Harnessing such information is valuable in highlighting the impacts of interventions targeted at increasing employment, including investments in infrastructure. The ILO/EU's STRENGTHEN2 project, which is demonstrating how to leverage employment impact assessments (EmpIAs) for the creation of more and better jobs in sub-Saharan Africa, has been using NTL data to assess the impact of infrastructure investments. This brief discusses the use of NTL data to conduct EmpIAs of road interventions and provides case studies of assessments and discusses the key findings, associated challenges and opportunities of utilising such data for measuring economic impact.

Nighttime lights as a proxy for economic growth

Nighttime lights satellite images provide values of light emissions captured at night. Aboard the NASA/NOAA Suomi NPP satellite mission, the Visible Infrared Imaging Radiometer Suite (VIIRS) captures light down to a ~500m spatial resolution. Common uses of the data include studying population, electrification and proxying for economic activity. Henderson, Storeygard and Weil (2012) were among the first to demonstrate the applicability of nighttime lights for measuring economic activity, in the form of GDP growth. Since then, this relationship has been tested to estimate GDP at a range of spatial scales, from national down to pixel-level (Zhao et al. 2017).

Attention has also been given to applying NTL data to assess the economic benefits created from transport infrastructure. The construction of roads plays a key role in poverty reduction, through improving access to basic infrastructure and the labour market and allowing the population to seek more and better jobs. Analyzing the change in GDP by comparing areas receiving improved roads to those that have not, over time, has been conducted in countries such as Haiti (Mitnik et al. 2018) and the West Bank (BenYishay et al. 2018). While this relationship between NTL and GDP is becoming increasingly established, less work has been conducted on then translating these changes in lights to changes in employment. A study in India, Asher et al. (2021) find that employment among other development indicators is correlated with NTL. However, they also highlight the caveats of using this data for the interpretation of economic results. High variability of lights across different levels of aggregation and the applicability of lights-to-GDP elasticities should be taken into consideration.

Applying NTL in Employment Impact Assessments of road interventions

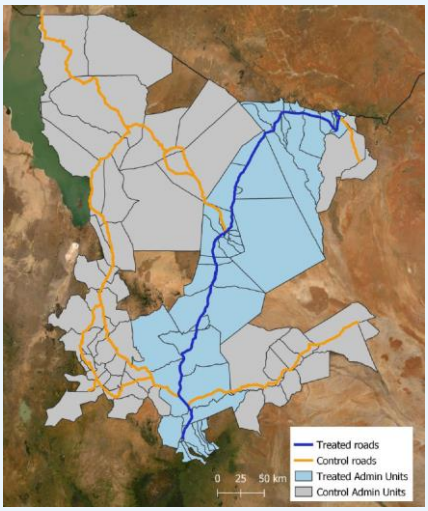
The STRENGTHEN2 project is a joint initiative of the European Union (EU) and the International Labour Organization (ILO) that focusses on job creation through investment. The project is conducting EmpIAs of EU-funded infrastructure programmes in a range of countries in SSA. One methodology that is being examined to measure the employment impact of infrastructure is the use of Geographic Information Systems (GIS), including the application of NTL data. In many countries in SSA, the lack of traditional indicators and up-to-date microdata on economic activity and employment make NTL a valuable source.

As with all datasets, there is a need to be aware of potential quality issues when applying the NTL data. NASA's Black Marble dataset was used in the following case studies, which is corrected for contaminated pixels due to cloud-cover and background lights. Data was further de-seasonalized and processed for use in the analysis.

Case Study 1: The Merille-Marsabit road, Isiolo to Moyale transport corridor in Kenya

The Isiolo to Moyale transport corridor involved the rehabilitation of 500 km of road in Kenya. The project aimed to facilitate trade between Kenya and Ethiopia and offers increased employment opportunities to the local population.

The EmpIA applied NTL data to measure the long-term impact the corridor produced on economic activity in the form of GDP and employment (Game and Kang 2023a). Using a difference-in differences-approach[1], it was estimated that the rehabilitation of the transportation corridor resulted in an increase in NTL surrounding the road up to 13 per cent two years after completion. This was estimated to translate into a 5.4 per cent increase in GDP and a 1.7 per cent increase in employment. The high resolution of the NTL data allowed the analysis to be conducted at both the administrative and pixel level, uncovering that impacts were highest within 2 km of the road intervention, an insight that can feed into evaluating existing policies related to roads. In order to control for factors that could influence the NTL values, data on population, other infrastructure and conflicts were incorporated into the analysis.



Study area of the Isiolo-Moyale EmpIA in Kenya, highlighting the roads and administrative units included in analysis.

Case study 2: National Feeder Roads Programme (NFRP) in Rwanda

The NFRP in Rwanda consisted of the rehabilitation and maintenance of rural roads across seven districts in Rwanda, with the main aim of connecting agricultural areas with markets.

Applying the same methodology (Game and Kang 2023b), the results from the EmpIA showed that NTL brightness increased by 2.3 per cent as a result of the project, two years after completion. This was estimated as equivalent to a 0.8 per cent increase in GDP and 0.3 per cent increase in employment.

The presence of other infrastructure projects, that included the construction and rehabilitation of other road programmes within the study area and time period of interest were controlled for. It was found that the impact on lights was larger, with an estimated 4.8 per cent increase in lights from the presence of other completed road programmes. This indicates that NTL are a useful proxy for investigating the economic impacts from larger road projects, which made up the other completed road

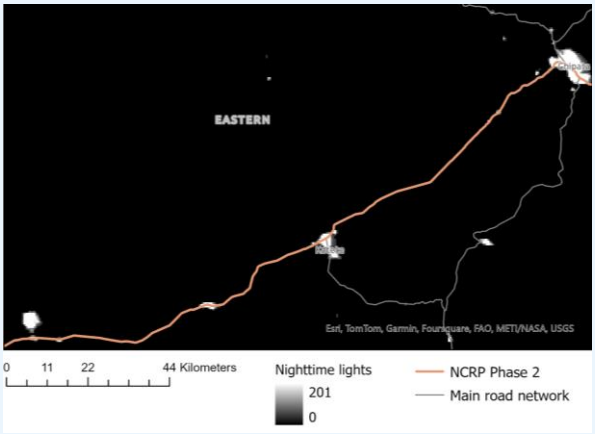
[1] In order to control for factors that could influence NTL values, data on population, presence of other infrastructure projects and conflicts were included in the analysis.

programmes in the study area. The data may be more valuable for understanding the impacts of projects of this scale, compared to smaller roads in rural areas.

Case study 3: The Nacala Road Corridor Project (NRCP) in Zambia

The NRCP project, aimed to provide transport linkages to the Nacala port, whilst improving accessibility for communities to markets. Phase 2 of the project covered 360 km of road works from Luangwa to Mwami.

The results showed that the road increased NTL brightness by 25 per cent in areas that benefitted from the road programme compared to areas around roads that did not receive works. This is estimated to lead to a 12 per cent increase in local level GDP and 6.7 per cent increase in employment. These results were similar in magnitude to the transport corridor in Kenya, reiterating the applicability of applying this data to assess the impacts of transport investments, particularly larger projects.



NTL data over Zambia and the part of the NRCP studied in the project.

Discussion

Transport corridors vs rural roads

NTL offer a suitable methodology for measuring the impacts of larger roads, such as transport corridors, as demonstrated in the above examples and previous literature. Often these road programmes aim to connect existing economic centres that have more economic activity. This is compared to rural roads where NTL may be less reliable in areas with sparse settlements, which will generate lower levels of light and may have limited access to electricity. Rural road projects also typically aim to connect agricultural areas to markets, which may lead to an increase in employment dimensions related to incomes, wages and working hours for the affected population, which will not necessarily be manifested in an increase in NTL. Based on the findings above, it indicates that NTL are a valuable proxy for economic activity and can be adopted to measure the impacts of road investments, but the characteristics and magnitude of such interventions may deem NTL data more suitable in some cases than others.

Endogeneity

A key issue with examining the economic and employment impacts of road interventions is endogeneity. The prioritization and placement of roads in projects is often not exogenous in nature. Political, economic and social reasons often serve for the non-random placement of programmes, where investments could either favour areas that show promise for economic growth or prioritize less developed areas.

In order to address this issue, a difference-in-differences-econometric approach can be applied, which is the case of the studies above. As outlined in Berg et al. (2015), this and other methods including instrumental variable strategy and restricting the sample to focus on 'inconsequential areas' can be adopted to introduce exogenous variation. With large projects such as transport corridors, the end points can usually be argued as being endogenous nodes. Omitting these end points of corridors is another measure that can be put in place to reduce the issue of endogeneity.

Policy implications

Compared to some other methodologies for EmpIA, the use of NTL data allows to examine the long-term impacts of infrastructure programmes, through an ex-post assessment. This can provide policy makers with information on the lasting effects of such interventions, which can feed into future policy setting and decision-making. The temporal aspect of data enables not just a sense of the size of the impact, but also informs how much time it takes for the impacts to be observed and reach the maximum. The high resolution of the data also allows the examination of the geographic variation in effects. From both studies, it was discovered that positive effects were observed within 2 km from roads, which provides important insight for planning of road placement.

Additional data

NTL provide the ability to estimate economic growth and employment with little data input required, but supplementing with additional information, such as Labour Force Survey (LFS) data, allows further dimensions of employment to be explored. This can provide insight into changes in sectors, occupations, incomes and employment quality. Depending on the project context and local characteristics, these shifts in employment outcomes may be more readily observed, compared to a sheer increase in number of new jobs created.

Recommendations

This work applies a methodology that can be used to estimate the employment impact of infrastructure projects in sub-Saharan Africa. Operationalizing the use of NTL data for EmpIA provides an approach to capture the long-term effects of programmes. Data is readily available at regular time intervals and globally, providing a resource-effective solution to measure economic impacts. Based on the results of the highlighted studies and further literature, NTL can be applied as a proxy for GDP and employment to measure the impacts of road investments across different countries.

Results coming out of these studies can be channelled into policy and planning of transport investments. The long-term impacts of projects are generally the main reason for investing in transport in the first place but are the most difficult to capture. This methodology offers a way to measure these effects at the local project level. Understanding the geographic scope of effects can feed into planning of future road placement to ensure targeting of intended beneficiaries. Being able to measure the economic and employment outcomes of these investments are key for the reporting of project donors. The ability to compare results from the same dataset across different investments and countries can provide insight into which projects or local characteristics lead to the generation of more economic activity and employment, which can be factored into decision-making on future investments. This analysis can also be applied to other infrastructure projects, such as rail, agriculture or energy.

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Contact details
International Labour Organization
Route des Morillons 4
CH-1211 Geneva 22
Switzerland

T: +41 22 799 7239
E: strengthen2@ilo.org
EMPINVEST@ilo.org

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