Harnessing satellite data to measure progress towards decent work and economic growth

Alina Game, International Labour Organization, Switzerland, game@ilo.org

Abstract

Assessing economic growth and employment is key for measuring progress towards SDG8, aimed to promote the creation of sustainable and inclusive decent work. For countries that lack traditional data sources and indicators, particularly at the local level, remotely sensed satellite imagery can be utilised to assess changes in economic outcomes, which can be translated into employment. Harnessing such information is valuable in analysing economic shocks from events and highlighting the impacts of interventions targeted at increasing employment, including investments in infrastructure. Satellite data can be applied to monitor response to environmental variability, such as changes in agricultural productivity from climate change, which is valuable for predicting changes in employment and livelihoods for affected populations. This data can be used as a proxy in locations that do not have access to relevant, up-to date information, but for areas where data is available, combining these insights with more traditional data sources, such as surveys, can provide a more comprehensive picture of decent work. It is recommended that this data continue to be implemented in applications relating to assessing economic and employment outcomes, however paired with an awareness of data quality and sensitivity of the information.

Remote sensing for economics

Geographic Information Systems (GIS) are designed to capture, store, process, analyse and visualise geographic, or spatial data. Satellite imagery is an example of spatial data, obtained through remote sensing, which is the process of collecting information on physical characteristics of the Earth's surface via satellite or aircraft.

There has been a growing impetus surrounding the utilisation of remotely sensed data within economics. Satellite data has been applied to economic analysis across many fields to investigate changes in nighttime lights, agricultural productivity, urban development and climate change. The International Labour Organization (ILO) STRENGTHEN2 project, is utilising satellite data and applying GIS to assess long-term impacts of infrastructure investments in sub-Saharan Africa. Such interventions are targeting employment generation and seeking to improve decent work outcomes. Assessing the progress made towards this is essential for future policy and data-driven decision making.

Satellite data carries the advantages of wide geographic coverage and offers a less resource-intensive approach compared to survey or other 'traditional' data collection methods. The high spatial resolution allows analysis to be conducted at the local level, often down to the pixel. Data is collected at regular time intervals, which is valuable for exploring temporal trends. These advantages should be balanced with an awareness of the caveats associated with such data, which varies between sources. Understanding the processing requirements and quality assurance of datasets is key for the appropriate application to different economic analyses.

Nighttime lights to measure economic growth and employment

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. Uses of the data include studying population, electrification and as a proxy for economic activity. Henderson et al., (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., 2016). It has been applied to analyse economic shocks to events such as the COVID-19 pandemic in China (Charpe 2022) and in India (Dagsputa, 2020), where a decrease in lights from the pandemic produced an estimated contraction in GDP of 24% which coincided with official Government figures. Further research is going into expanding the applications to estimate the economic loss from events such as natural disasters and conflicts.

Attention has also been given to applying nighttime lights to assess the economic benefits created from transport infrastructure. The construction of roads play a key role in poverty reduction, through improving access to basic infrastructure and the labour market, allowing the population to seek more and better jobs. Analysing 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). Where this relationship between nighttime lights and GDP is becoming increasingly established, less work has been conducted on then translating these changes in lights to changes in employment. The STRENGTHEN2 project has explored this when conducting employment impact assessments of road interventions in sub-Saharan Africa (Game and Kang, 2023). In Kenya, it was estimated that the rehabilitation of a transportation corridor resulted in an increase in lights surrounding the road up to 13%, two years after completion. This was estimated to produce a 5.4% increase in GDP and 1.7% increase in employment. The high resolution of the nighttime lights data allowed the analysis to be conducted at both the administrative and pixel level, uncovering that impacts were highest within 2km of the road intervention, an insight that can feed into evaluating existing policy surrounding roads. Within these studies, it is important to control for factors that could influence nighttime lights, such as population, other infrastructure and events e.g conflict, which requires additional information that can also be obtained from spatial data sources.

Nighttime lights 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. These shifts in employment outcomes may be observed more, compared to a sheer increase in number of new jobs created.

Satellite imagery and agricultural productivity

The agricultural sector is extremely vulnerable to environmental variations and the impacts of climate change. For people employed in agriculture or involved in subsistence agriculture, increases in temperature, a reduction in precipitation and other effects will impact agricultural productivity which will negatively influence incomes and livelihoods of affected populations. Indices derived from satellite imagery, such as the Normalized Difference Vegetative Index (NDVI), providing a measure of vegetation health and the Normalized Difference Water Index (NDWI), a proxy for plant water stress, can be integrated in crop yield models to aid in prediction and forecasting (Bolton and Friedl, 2013). Previously, remotely sensed data was often supplemented with ground truth data on crop information, however this field data collection is resource intensive and not always possible. In recent years, higher resolution imagery, such as that collected from Unmanned Aerial vehicles (UAVs) equipped with sensors have been applied to precision agriculture (Jung et al., 2021). To work with the big data that is being retrieved from remote sensing, much recent work has focussed on utilising deep learning, to analyse large datasets and learn the relationships between various variables (Muruganantham et al., 2022).

Understanding the impacts of environmental changes on agricultural productivity is valuable to evaluate vulnerability and subsequent risks to livelihoods and employment outcomes. Predictions of crop yield loss can be used to estimate the effects on incomes for farmers. Identifying affected areas is key for targeting investments geared towards adaption and mitigation of the effects. Examples such as Nature-based Solutions (NbS), when applied to the agricultural sector, can increase resilience whilst mitigating the effects of climate change. Such interventions can also be labour intensive and provide opportunity for decent job creation. To the opposite effect, the same remote sensing techniques can be applied for evaluating the progress that these interventions are making to assess their effectiveness.

Recommendations moving forward

It has been highlighted that lack of data is one of the major limiting factors in monitoring progress towards implementing the SDGs, particularly in low and middle income countries. Satellite imagery among other innovative data sources offers huge potential for monitoring progress at timely intervals and high spatial scale. This highlights examples of some of the applicable areas of remote sensing for measuring economic growth and employment outcomes.

Although the data offers promise, users should be aware of the quality of data they are accessing and the need for rigorous quality checks and pre processing of satellite data required in analysis. The use of this data alone is not entirely a substitute for traditional data sources and where available, should be complimented with additional information to increase accuracy of results. For places where traditional data is not available or during events such as natural disasters, it can provide a timely and cost effective solution to measure economic impacts.

Much research is going into exploring the use of satellite data and its relationship with the economy and employment. There is a need to pair research using satellite data to measure economic outcomes with real life applications to operationalise the use of remote sensing for the promotion of decent work. It is encouraged that stakeholders share relevant data and knowledge to expand this area of work. In parallel to this, an awareness of the ethics and sensitivity surrounding datasets should be exercised. As technology advances and data increases in detail, clear rules need to be in place to prevent the misuse of data.

References

BenYishay, A, et al., 2018, Final Report: Evaluation of the Infrastructure Needs Program II, AidData at William & Mary

Bolton, D and Friedl, M, 2013, Forecasting crop yield using remotely sensed vegetation indices and crop phenology metrics, Agricultural and Forest Meteorology, 173

Charpe, M, 2022, The Economic Impact of Covid-19 and Associated Lockdown Measures in China, MPRA Paper No. 114861

Dagsputa, N, 2020, Using satellite images of nighttime lights to predict the economic impact of COVID-19 in India, Advances in Space Research, 70

Game, A and Kang, X, 2023, Employment Impact Assessment of the Merille-Marsabit road, Isiolo-Moyale transport corridor in Kenya, International Labour Organization

Henderson, J, et al., 2012, Measuring Economic Growth from Outer Space, The American Economic Review, 102

Jung, H, et al., 2021, The potential of remote sensing and artificial intelligence as tools to improve the resilience of agriculture production systems, Current Opinion in Biotechnology, 2021

Mitnik O, et al., 2018, Bright Investments: Measuring the impact of transport infrastructure using luminosity data in Haiti, IZA Discussion Paper No. 12018

Muruganantham, P, et al., 2022, A Systematic Literature Review on Crop Yield Prediction with Deep Learning and Remote Sensing, 14

Zhao et al., N, 2016, Forecasting China's GDP at the pixel level using nighttime lights time series and population images, GIScience & Remote Sensing, 54