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Measuring the impact of development projects using geospatial impact evaluation methods

Geospatial impact evaluation (GIE) methods were developed because of the increasing availability of geospatial data. They are particularly suited to evaluating the impact of development aid programmes i) when the impacts can be observed from the sky, ii) when it is complex or very costly to obtain impact indicators, iii) when the area of interest is relatively large or difficult to access, iv) when a portfolio of projects is being studied, v) when the intervention has already taken place and a retrospective evaluation is required. This innovative method increases the possibilities to extend the level of analysis and the range of subjects being studied.

What is a GIE method?

Counterfactual impact evaluations (IEs) are used to determine which development programmes or interventions are most effective, while also measuring their causal impact on the wellbeing of beneficiaries[1]. Counterfactual impact evaluations are based on comparing over time the impact indicators of a group of individuals or an environment (the "treatment group") with a similar group not exposed to the intervention (the "control group"). There are two major families of counterfactual IEs and they differ in their counterfactual approaches. On the one hand, there are experimental IEs, known as *Randomized Controlled Trials* (RCTs), in which the random selection of a treatment group facilitates comparison with the control group, and on the other hand, there are quasi-experiments applied to interventions for which the treatment group is pre-defined during the development of the intervention, meaning that the control group must be identified *retrospectively*.Geospatial impact evaluation (GIE) is a quasi-experimental method characterised by the type of data it harnesses. In practice, GIE makes use of geolocation data, and offers significant benefits in some specific contexts.

[1] Counterfactual describes a programme beneficiary's situation if the programme had not existed. By definition, counterfactuals cannot be directly observed. Consequently, they have to be estimated, for instance by making use of control groups.

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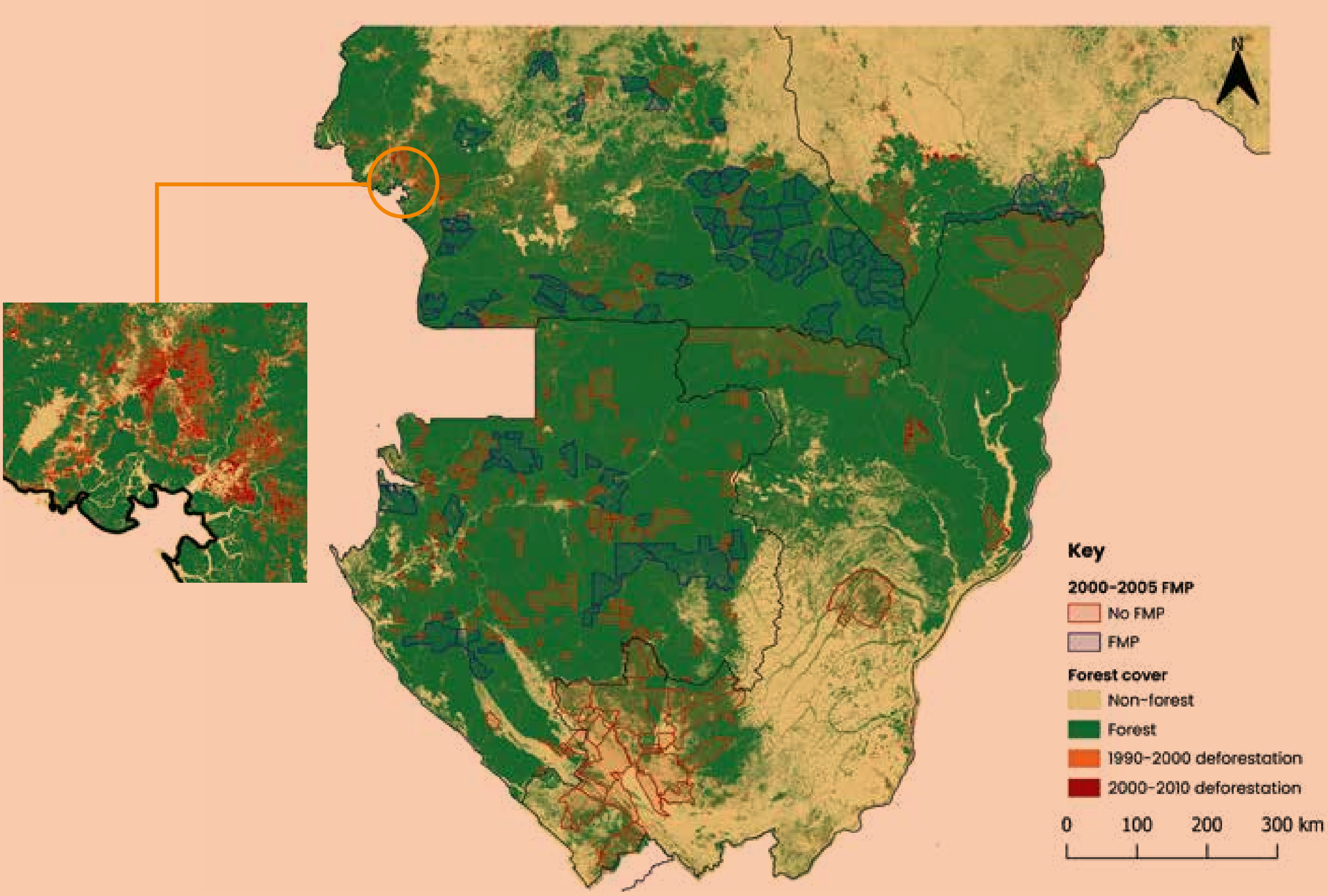
Box 1 – A GIE used to analyse the impact of forest management plans on deforestation in the Congo Basin

Given the importance of the forest sector, sustainable forest management, which can consist in forest concession management and certification, is regarded as an important forest conservation instrument. It enables to reconcile biodiversity conservation, economic production, and local development. However, there is still debate regarding the effectiveness of these instruments in avoiding deforestation, both in institutions and NGOs, and in the scientific community. In this context, the study by Houngbedji *et al.* (2020) funded by AFD and FFEM (the French Facility for Global Environment) uses GIE methods to identify the impact of forest management plans (FMP) on deforestation in the Congo Basin, supported for over two decades by various development stakeholders. The analysis makes use of official records for forest concession activities and satellite imagery to quantify deforestation in the studied region, so as to compare the situation in zones with forest management plans with a counterfactual situation. The findings show that the adoption of a forest management plan cut deforestation by 74% across the period under study. Phase two of this study, also funded by AFD, was launched in early 2022 in order to further evaluate environmental impacts since 2010 and add another dimension of analysis focusing on the impact in terms of individual wellbeing.

Map 1 – Location of treatment and control concessions for the 2000-2005 FMP test



Source: taken from Houngbedji *et al.* (2020) using national forest monitoring maps, WRI atlases, and then OFAC data.

Note to the reader — The map (on the right) distinguishes between the concessions that have implemented a forest management plan (FMP) and those without one, over the study period (2000-2005). In the zoomed view (on the left), the pixels showing deforested areas over the 1990-2000 period (orange) and 2000-2010 (dark red) can be seen. The impact of the FMP is measured by comparing the deforested area in the managed concessions with the area in the unmanaged concessions.

The GIE approach: a burgeoning trend with several benefits

The GIE method has been increasingly used over the past few years because of the growing availability of georeferenced data from development projects and spatial data in terms of volume, scope and periodicity, enabling the development of performance indicators at the individual level or larger spatial scales.

Just like other quasi-experimental IE methods, one of the primary benefits of GIE methods is the possibility of retrospectively estimating the impact of an intervention, i.e., after it has taken place. In fact, a large amount of geospatial data is collected regularly (on a daily or weekly basis), and is sometimes made available for free by the institutions collecting them[2], or can be purchased directly from private geospatial data providers[3]. Access to historical data going back several years and sometimes covering the whole world, depending on data characteristics and accuracy, makes it possible to measure impact by looking before and after the intervention, in treatment and control areas.

Until a few years ago, IEs mainly focused on measuring the impact of a specific type of intervention on beneficiaries, but the combination of spatial data on interventions and on impact indicators, together with quasi-experimental IE methods, is broadening the range of dimensions that can be studied and the scale of analysis. In fact, the GIE method allows to estimate the impact of a portfolio of projects (donor-specific, or sector-specific), for which the location and implementation period are known, across large areas of intervention, thus offering the possibility of better identifying the impact of development aid. The option of running a large-scale analysis also has external validity benefits.

GIE methods can also facilitate the measurement of the impacts of an intervention considering that they tend to be significantly less expensive and quicker to roll out than other counterfactual methods. Indeed, if the georeferencing information of the programme being studied is known and the performance indicators from the area of intervention are accessible, on average a GIE can be undertaken in less than a year at an estimated cost of US$100,000-US$150,000 (BenYishay *et al.*, 2017). In comparison, implementing a RCT or large-scale counterfactual IE can on average take five or more years, and cost between US$500,000 and US$1 million due to the need for control and treatment groups data collection before and after the programme is rolled out (BenYishay *et al.*, 2017).

[2] An example is the European Space Agency's Sentinel programme, and NASA's Landsat programme.

[3] As Airbus, Maxar Technologies and Planet do.

What are the pre-requisites for applying a GIE?

Programmes and interventions that can be evaluated using this approach must be spatially heterogeneous, i.e., the programme considered must cover a specific known area, and there must be other comparable areas not exposed to the programme. However, if this condition is not met, it is nevertheless possible to exploit the time-related potential heterogeneity of programme deployment across zones. On the other hand, if the programme does not fulfil either of these two criteria, the GIE method cannot be utilised to assess its impact. For example, a debt cancellation, or a nationwide homogeneous intervention do not lend themselves to a GIE-type evaluation.

There are three additional pre-requisites for applying the GIE method. Firstly, it is essential to have precise georeferenced data for the intervention (geographical scope or geolocation). Secondly, as the GIE approach is also based on an historical and temporal dimension, it is necessary to have precise information on the start date of the project. Finally, the impact indicators of interest must have both temporal and spatial dimensions. More specifically, the available data must cover the area of intervention and the control area before and after the intervention. If the intention is to conduct a cost-benefit analysis using GIE, the amount invested in the intervention also needs to be known.

It is important to note that in some cases, analysis of geospatial data and in particular of satellite imagery requires the collection of field data to calibrate the models. This sort of data is also called training data when used to feed *machine learning algorithms*. Consequently, when producing land use maps or accurately forecasting crop yields, the availability and quality of these data are sine qua non conditions for obtaining reliable results.

What types of interventions are suited to the GIE method?

Given the aforementioned pre-requisites, GIEs are particularly suited to evaluating the impact of projects or portfolios of projects with a defined environmental or socioeconomic impact.

Many different types of interventions aim at having a positive impact on the environment, for instance by protecting natural capital assets, or supporting agricultural production. This is the case for projects centered on the implementation of protected areas, the deployment of irrigation systems, or any other programme aiming at limiting deforestation and the destruction of natural habitats, or increasing agricultural productivity. Therefore, satellite imagery can easily be used to track forest cover and vegetation change, in particular through the use of vegetation indices generated using non-visible bands (i.e., near-infrared) of optical imagery and enabling chlorophyll content to be detected. Furthermore, *machine learning algorithms* can be used to segment and classify each image to track changes in land use, such as habitat fragmentation or changes in the urban built up environment, which allows to detect an intervention's environmental impact, or the impact of the construction of infrastructure on natural capital assets. Finally, it is possible to detect the type of crops grown in a specific area by combining vegetation indices and harnessing classification algorithms, enabling agricultural productivity to be monitored.

Other interventions focus on making a socioeconomic impact on individuals, or on geographical areas that vary in extent, making them more difficult to observe. This is the case for projects aiming at facilitating access to basic services such as electricity or water, transport infrastructure, or any other programme with an impact on household well-being or business activity. As such, the impact of projects or portfolios of projects on health, poverty and living standards of individuals or on business productivity can be studied using data from georeferenced household or business surveys (Wayoro *et al.*, 2020). If such georeferenced data do not exist, some socioeconomic impacts can be evaluated through proxies using satellite imagery, particularly when the indicators used are closely correlated with the expected impacts. For example, nighttime lights is increasingly used to measure local economic development, and is closely correlated with the emission of artificial electric light (Civelli *et al.*, 2017). Moreover, analysis of very high-resolution imagery (< 1 m) coupled with machine learning algorithms allows to detect the quality of roofing materials used on houses, and therefore obtain information on household standards of living and wealth, in both rural and urban areas (Huang *et al.*, 2021).

Therefore, the application of GIE methods can be adapted to many areas of intervention in order to estimate development project impact. However, usage of these project impact evaluation methods by development stakeholders, particularly development banks, remains limited. This stems from a lack of awareness and internal expertise on geospatial data and geospatial analysis techniques. While institutional internal capacity-building is needed, the scale of the transformational change which must be carried out, and the expertise needed to deploy these solutions, tend to require support from external geospatial experts and institutions. In the context of development banks, national and international space agencies have positioned themselves as strong partners. For example, the World Bank and the Asian Development Bank both receive support from the European Space Agency and AFD has also recently strengthened its links with CNES (France's National Centre for Space Studies).

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