Learning brief

Agriculture, fishing, and forestry

Evaluating agriculture in Niger using remotely-sensed data: preliminary lessons

Climate change is exacerbating food insecurity around the world, particularly in drought-prone areas that are already highly vulnerable, such as the Sahel region of West Africa. A number of projects are being implemented throughout the region to combat this threat; however, they are difficult to monitor and their effectiveness is uncertain. With an increase in the availability of high-quality open-source satellite data on relevant indicators (e.g. cultivation, vegetation growth, or poverty), there has been a rapidly growing interest in leveraging this data for evaluations, especially in remote and fragile contexts where high-frequency and granular data may not be available on the ground.

To improve food security and resilience, the government of Niger, with funding from the West African Development Bank (BOAD), implemented a multi-faceted agricultural production intensification program in 2011 (PIPA/SA). The BOAD commissioned this research team to measure its impacts using remotely-sensed data.

Highlights

- Vegetation and agricultural production increased in two project regions, according to preliminary results.
- These preliminary results do not necessarily show whether the project caused the results – however, these increases are promising indications that an impact evaluation should be conducted to rigorously measure its impact.
- Remotely-sensed data accurately reflected the expected seasonality in Niger, highlighting the need to account for changes in rainfall, particularly for regions that are sensitive to climatic events (floods or drought).
- Remotely-sensed data on water levels may not be accurate or reliable in regions that are extremely arid and dry and require more granular analysis on closely defined bodies of water.

Background

The Republic of Niger is emblematic of the problems in the Sahel, with historic droughts and complex emergencies, where measuring the changes in climate and vegetation from above can be incredibly valuable. In 2020, Niger's population was approximately 24.21 million, 49.7 percent of whom were under 15 years old and 83 percent of whom live in rural areas, according to World Bank data. Two thirds of the territory is desert. Less than 300 mm of rain falls annually in nearly 75 percent of the country, presenting challenges for intensive agriculture and making the region particularly vulnerable to food insecurity and climate change.

In response to a severe food crisis in 2007-2008, the West African Economic and Monetary Union (WAEMU) and the West African Development Bank (BOAD) initiated the Special Food Security Program to support countries' efforts to develop the region's agro-pastoral potential and to boost agricultural production.

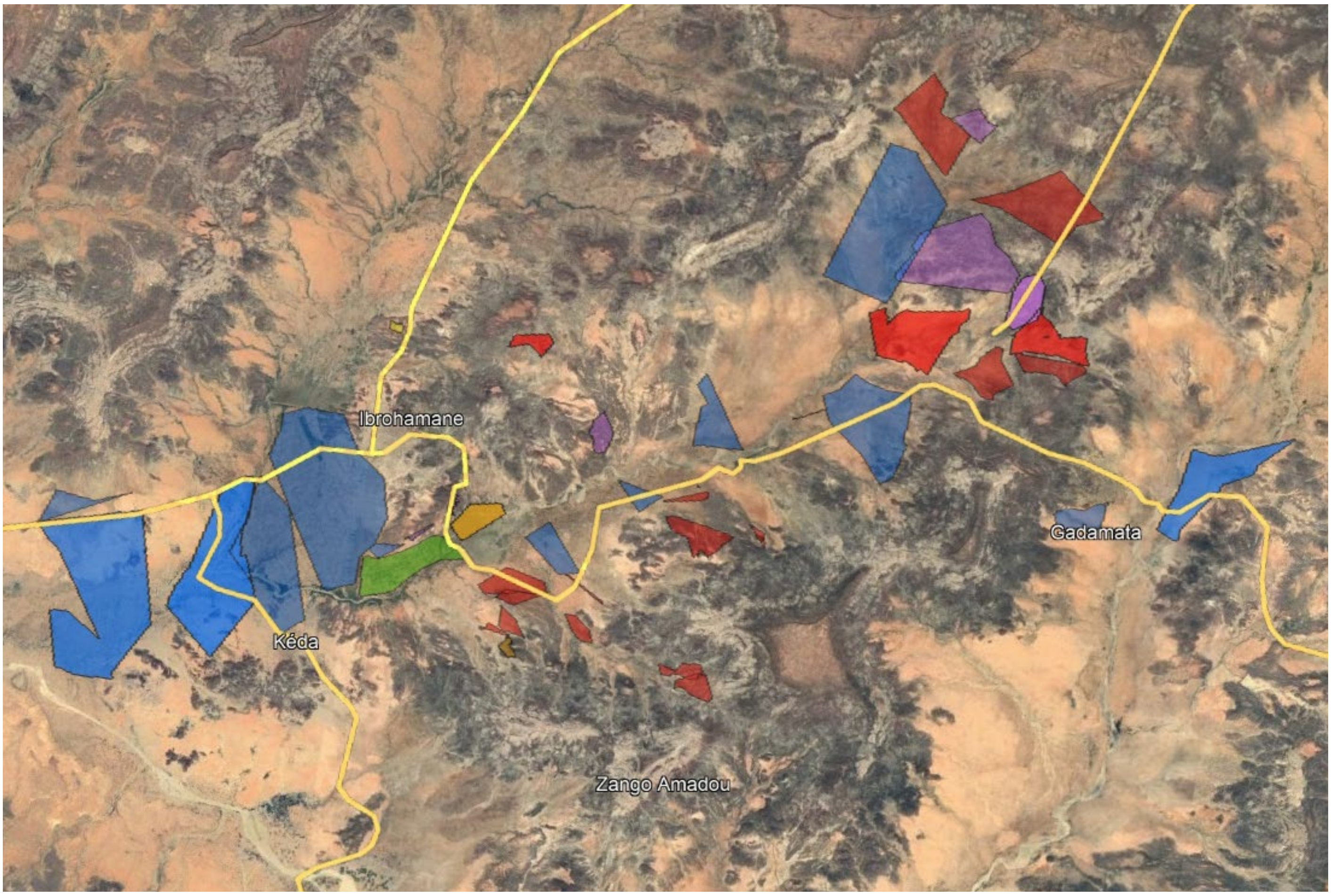
Seventeen projects were approved across the eight WAEMU countries, targeting 5 million people. Their goal is to contribute to the self-sufficiency and food security of the rural poor by: developing at least 7,700 ha with irrigation systems and related basic infrastructure; constructing dams and hydro-agricultural developments; strengthening storage capacities; improving the organization of producers; granting microcredits; installing boreholes; upgrading markets; and building other community infrastructures.

In Niger, the Agricultural Production Intensification for Food Security Project (PIPA/SA) started in 2011 with two goals: increase irrigated crop production and increase rainfed crop production.

Currently, the PIPA/SA program has a completion rate of 97% across the three project sites, however, only two of the irrigation perimeters are operational.

Due to the remoteness and political instability, it is difficult measure the project's effects using traditional methods. So the BOAD commissioned the International Initiative for Impact Evaluation (3ie), along with our partner New Light Technologies (NLT), to analyze key outcomes related to the program including changes in agricultural production, water availability, siltation, and desertification using remotely sensed data. Geo-spatial data provides an important window to see what is happening at the project sites; it allows for monitoring, supervision, and coordination with on-the-ground teams. For the BOAD, satellite and GIS data diminishes the information asymmetry, adds transparency, and can provide real time supervision. In this study, we worked with the implementation teams in Niger for "ground-truthing" and details of the implementation.

Map 1: Map of project components in the Ibohamane Region



Main findings

Overall, we see steady increases in greenery over time in regions where rehabilitation and irrigation perimeters were implemented, particularly compared to before these interventions occurred. However, work is needed to isolate the impact of the rehabilitation efforts.

There is an increase in greenery (as measured by satellite proxy NDVI) in Ibohamane and Dogueraoua project areas over time, particularly following the implementation of the irrigation perimeter/rehabilitation program in 2018. As depicted in the graphs below, where the dashed line illustrates when the irrigation perimeter was completed, there is an increase in greenery (NDVI) in Ibohamane (red) and Dogueraoua (purple) after the perimeter begins to be used. In comparison, we see a slight decrease in the Niamey region (grey), where there was no change in perimeter use or rehabilitation efforts until very recently. These results imply that the program may have played a role in increasing greenery and cultivation in Ibohamane and Dogueraoua. These results held true even when accounting for changes in rainfall or repeating the analysis using the SAVI indicator, which accounts for soil brightness when vegetation cover is low. The impact evaluation following this analysis will provide insight into whether the increases we see are due to the intervention or other factors.

Figure 1: Average Yearly NDVI 2010-2022: Actual

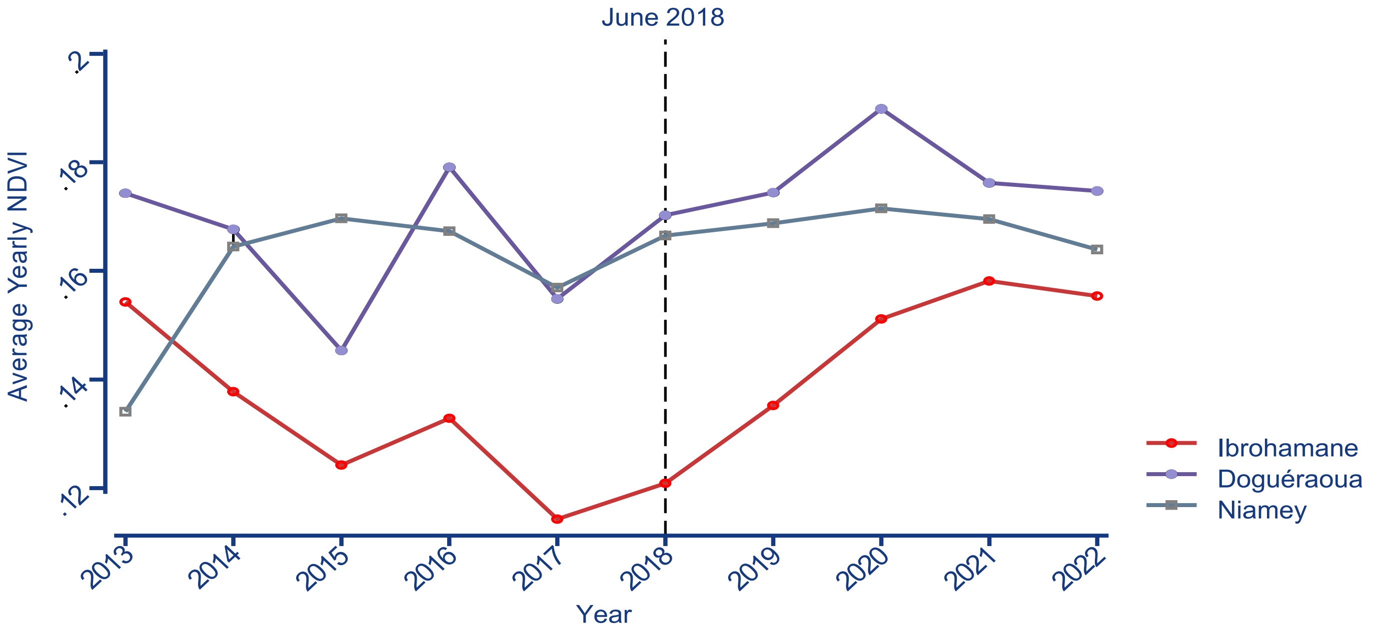
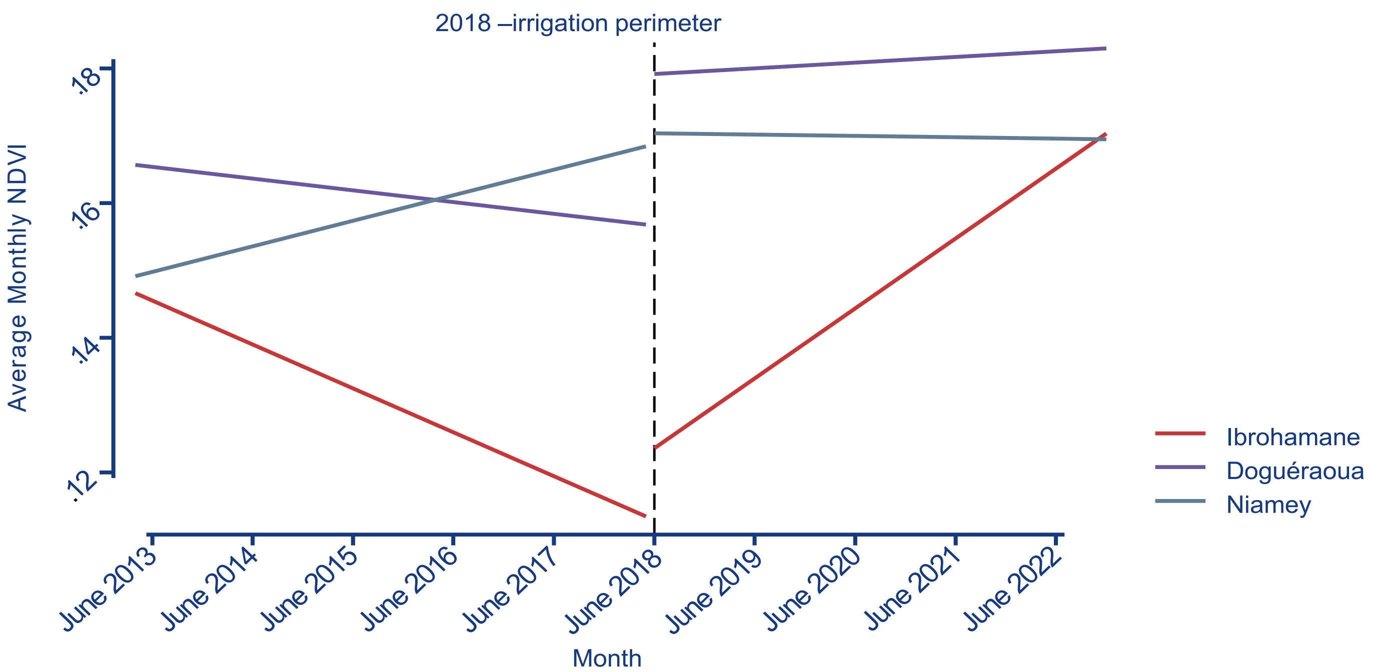


Figure 2: NDVI 2010-2022: Fitted Line

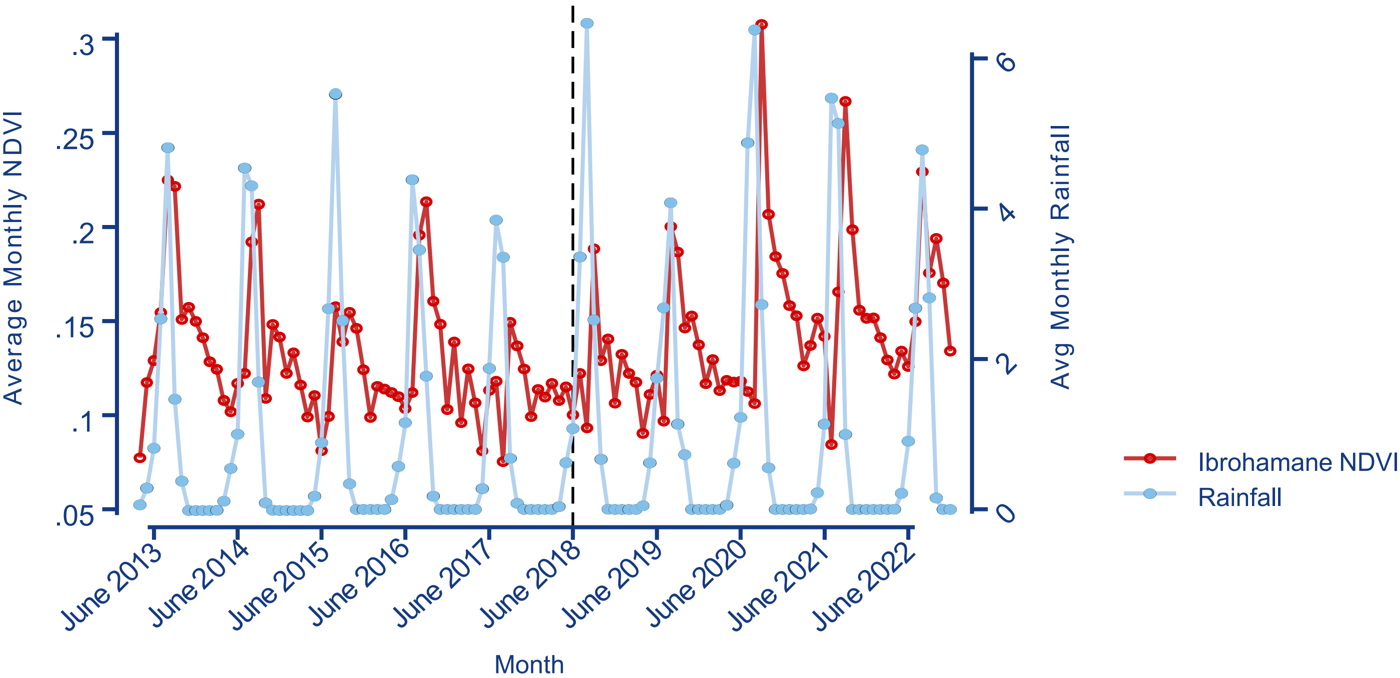


Main findings

The remotely-sensed measure of water, NDWI, did not appear accurate for this context. Since the regions for which the water level is measured primarily consist of rocks and sand, the water levels are being measured as being below zero, indicating that there is no water in these regions on average and any change we see measures rocks/sand/built-up structures rather than water. This measure is likely to be more useful in analyses that focus on a smaller region with higher concentrations of water. This result emphasizes the need to fully understand what each remotely sensed indicator is measuring and carefully select indicators that are valid in a specific context.

Seasonality needs to be considered when evaluating changes in vegetation or agriculture. As expected, and illustrated in the graph below, vegetation in Ibohamane increases at times when there is more rainfall. Both the levels of greenery and rainfall are far higher from June to November than in the months of December to May. To account for this seasonality and the fact that increases in rainfall after the intervention may be contributing to the increase in greenery we see, we include a control for rainfall and plan to perform an analysis by season.

Figure 2: **NDVI vs Rainfall in Ibohamane**



Implications for next steps

This preliminary analysis does not determine the impact of the program. While there is an increase in greenery after the program is implemented, the changes we see may be influenced by factors such as flooding or drought, or other farming/rehabilitation activities occurring at the same time as the irrigation program. It will be important for the next analysis to include valid control/comparison regions where the intervention did not occur, but where similar other activities may have, in order to isolate the impact of the program. Niamey is one such control region, but this preliminary analysis has illustrated that there may be other factors influencing the amount of greenery in Niamey that makes it less likely to be a valid comparison group, like its proximity to a consistent water source. Therefore, we are looking to establish a control group from various potentially similar regions by matching them to our treatment on various background characteristics, including precipitation, elevation, temperature, and baseline levels of greenery and water content.

It is important to carefully select and interpret the remotely sensed indicators/data based on the region and context. For example, satellite data measuring water levels may not be as relevant in regions with a lot of rocks, sand, and built-up structures. Instead, such data is most relevant when focused on specific water bodies to measure their change in level.

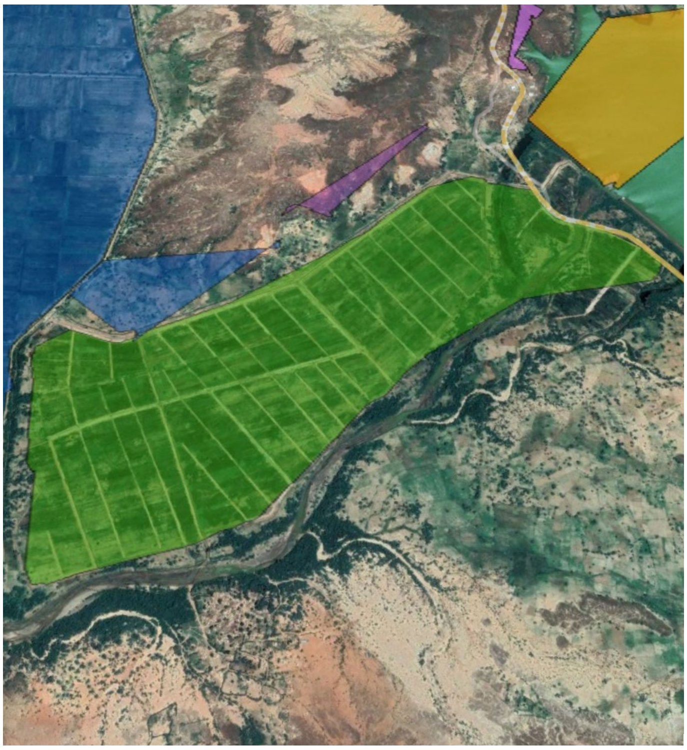
While remotely sensed data is easy and efficient to collect and use, ground truthing and quality assurance of the data is still essential. We worked with individuals on the ground to map the intervention areas using GPS mapping software, ensuring we had a granular and accurate understanding of what interventions occurred where. However, sometimes the software, or the individuals on the ground can make mistakes. Researchers need to be involved during data collection to understand why mapped areas may not align with intervention-related activity that can be seen from the satellite. For example, sometimes the satellite data shows rock walls exist both within and outside of the regions mapped by individuals on the ground. **While an evaluation of less granular regions can still occur with some measurement errors, for the data to be as accurate as possible, there needs to be close interaction with individuals on the ground.**

Future analysis will leverage the granularity of remotely sensed data to focus on specific intervention areas (such as the irrigation perimeter) rather than the average for the entire region. This approach will provide insight into the impact of the individual interventions, rather than the average impact for the region as a whole. We will also employ other satellite indicators to measure change in greenery (e.g., SAVE, EVI, GCVI) and changes in water levels in the dams and/or surrounding rivers (e.g., NDWI) . As mentioned, we will also use different methods and covariates (including precipitation, elevation, temperature, and soil moisture) to establish a counterfactual and isolate the impact of the intervention.

Map 2: Ibohamane Irrigation Perimeter

Oct 2016

Oct 2019



About this brief

This brief is authored by Fiona Kastel, Anca Dumitrescu, Sanchi Lokhande, and Douglas Glandon from 3ie with geospatial data provided by Selamawit Tesfay and Ran Golblatt from NLT.

The evaluation was sponsored by the BOAD and conducted by the International Initiative for Impact Evaluation (3ie) and New Light Technologies (NLT).

What is WACIE?

The West Africa Capacity Building and Impact Evaluation (WACIE) program was launched to help build evaluation capacity in the eight countries that comprise the West African Economic and Monetary Union (WAEMU): Benin, Burkina Faso, Cote d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal and Togo. Program goals include increasing evaluation capacity in targeted countries, ensuring that policymakers have access to relevant evidence and promoting the use of high-quality evidence by relevant stakeholders.

The West African Development Bank (BOAD)

The West African Development Bank (known by its French acronym BOAD) is the common development financing institution of the West African Economic and Monetary Union (WAEMU). BOAD is a public international institution whose purpose is to promote the balanced development of member states and to contribute to the achievement of economic integration in West Africa. The member states are: Benin, Burkina Faso, Côte d'Ivoire, Guinea-Bissau, Mali, Niger, Senegal and Togo. By treaty of the West African Economic and Monetary Union (WAEMU), the BOAD is a specialized and autonomous institution of the Union. It contributes "in full independence to the attainment of the objectives of the WAEMU without prejudice to the objectives assigned to it under the WAEMU Treaty".

New Light Technologies Inc. (NLT)

New Light Technologies Inc. (NLT) specializes in providing integrated consulting services with the agility and ingenuity needed for today's rapidly changing world. Our broad scientific, technology, and mission expertise enable us to deliver solutions for our customer's most complex challenges. At NLT, we are harnessing the growing availability of high resolution geospatial, remote sensing, imagery, and IoT data to offer real-time location-based and predictive analytics to help clients around the world with natural hazards risk analysis, monitoring agricultural productivity, transportation planning, economic development and more. NLT is intimately familiar with deriving the principal components that allow local administrators to establish policy and public health guidance in global regions such as Africa, the Asia Pacific, and South America.