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# Detection and mapping of agricultural large-scale land acquisitions (LSLAs) using MODIS Satellite Image Time Series

Yasmine NGADI SCARPETTA<sup>1,2,4</sup>, Valentine LEBOURGEOIS<sup>1,2</sup>, Mohamadou DIEYE<sup>3</sup>, Jérémy BOURGOIN<sup>1,2</sup>, Agnès BEGUE<sup>1,2</sup>, Anne-Elisabeth LAQUES<sup>4,2</sup>

<sup>1</sup> Cirad, UMR TETIS, Montpellier, France, *Yasmine.ngadi\_scarpetta; valentine.lebourgeois; jeremy.bourgoin@cirad.fr; agnes.begue@cirad.fr* ;

<sup>2</sup> Université de Montpellier, France

<sup>3</sup> ISRA-BAME, Dakar, Sénégal, *dieyemohamadou@gmail.com*

<sup>4</sup> IRD UMR ESPACE-DEV, Montpellier, France, *anne-elisabeth.laques@ird.fr*

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## Abstract

Large scale land acquisitions (LSLAs), often referred as “land grabbing”, are highly dynamic and complex land use systems that are rapidly transforming ecosystems and societies in many low-income countries of the world, bringing on one hand sustainability challenges and, on the other hand, undermining the right of peoples to self-determination over natural resources. As such, monitoring of those large-scale agricultural expansions has appeared to be of paramount importance. In response to that need, the Land Matrix international initiative has emerged to promote the creation of an open access database on world land transactions. This open tool enables the collection and visualization of data on land deals based on publicly available sources (i.e. from governments, corporations, medias, citizen). However, because information on those acquisitions is often opaque and scarce, systems allowing near real-time LSLAs detection, characterization and monitoring are needed.

In this context, the increasing availability of free-of-cost global satellite data products has shown great potential for providing insights into land dynamics, particularly of large and remote areas. While LSLAs are not directly observable from remote sensing images (no one-to-one relation between land cover and functionality), they may be inferred from observable land cover and spatio-temporal characteristics at different scales, and structural elements in the landscape. At a pixel level, land use and land cover (LULC) changes are often detected using change detection algorithms applied on temporally-dense satellite image time series (SITS) of vegetation indices. So far, most of the LULC change studies have focused on forested land covers where significant deviations (anomalies) from the mean are relatively easy to detect. However, LULC changes, and in particular human-driven ones such as those induced by LSLAs, often imply a change in (seasonal) interannual patterns (not always with significant shifts from the mean), that are less well detected by change detection algorithms. Accurate and automatic detection of those type of changes would thus pave the way for the development of generic and unsupervised approaches to LULC change detection.

This study deals with the detection of agricultural LSLAs under different environmental conditions. Focus is given on Senegal for which we have ground-truth data. In addition, its strong north-south gradient of rainfall from dry to semi-humid climate, and relatively small sizes of its deals make Senegal an interesting and difficult study case study for the detection of LSLAs. The detection method proposed here is based on a two-step approach: 1- the detection of (if any) breakpoints in dense MODIS 2000-2020 Vegetation Index (NDVI) time series using the very fast BFAST monitor algorithm. Because BFAST monitor algorithm is subject to a high false positive rate, we implemented a second step to select the breakpoint most likely related to the desired land use change (biggest pattern change), 2- the selection, for each pixel, of the breakpoint associated to the biggest phenological change, based on a time series distance computed between the subsamples before and after each breakpoint.

Results consist of change-intensity maps, date-of-change maps, and a comparison of the change detection maps obtained using our method vs. using the biggest BFAST-magnitude change detected. Areas potentially related to agricultural LSLAs are identified and qualitatively/quantitatively characterized (e.g. year of change, spatial expansion) and evaluated against field data (when available) and high spatial resolution spatial imagery (Landsat/ Google Earth). The method was also tested over different more humid and forested specific areas found in the literature (e.g. Laos and Mozambique), where agricultural LSLAs have been reported and characterized. For these areas we produced maps of deforested areas, with associated date-of-change, that could be assessed qualitatively. The results indicate that our method has a high potential for detecting LSLAs even in humid regions, and thus for mapping the extent and dynamics of deforestation driven by different types of commodities. Future efforts will focus on a finer assessment of the driving factor of the detected LULC changes (e.g. fire, forest management, commodities cropping etc.) through the application of image analysis techniques (clustering and object-based image analysis).