ADVANCE OF SOY COMMODITY IN THE AMAZONIA UNDER DEFORESTATION DATA VIA PRODES AND IMAZONGEO

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ABSTRACT

Decision making on deforestation in the Amazon has been efficient due to monitoring programs using remote sensing. Thus, our objective was to identify the expansion of soy farming in disagreement with the Soy Moratorium in the Amazon of Mato Grosso from 2008 to 2019. Deforestation data from PRODES and ImazonGeo programs were used. The PCEI was calculated using a cloud platform for soybean areas identification. The Mann-Kendall and Pettitt tests were used to identify trends across the time series. Our results revealed a difference between these programs on deforestation and forest-to-soy conversion areas. According to PRODES data, 1,387,288 ha were deforested from August 2008 to October 2019, of which 108,411 ha were converted to soybeans. ImazonGeo data showed 729,204 hectares deforested and 46,182 hectares converted to soybean areas. These results indicate that the PRODES system has greater data variability and higher averages than ImazonGeo.

Key words — Amazon, remote sensing, agricultural culture, public policies, sustainability.

1. INTRODUCTION

One of the ways to contain deforestation in the Amazon region was the agreements signed, such as the Soy Moratorium (SoyM), which provides for the non-commercialization of soy from deforested areas as of August 2008 [1] Despite these efforts, the forest continues to be illegally deforested and replaced by pastures and soy [2].

To verify these illegal deforestations, there are two databases freely available in Brazil. The Amazonia Deforestation Monitoring Project (PRODES), which is developed and executed by the National Institute for Space Research (INPE), and the Amazonia Geoinformation Program (SAD/ImazonGeo) developed by the Institute for Man and the Environment of the Amazon (Imazon).

The Perpendicular Crop Enhancement Index (PCEI), recently used in mapping soybean areas [3], [4], has been positively effective in monitoring soybean farming and has become an essential tool in monitoring the expansion of the crop in the face of deforestation in the Amazonia [2].

This study aimed to verify the conversion of forest into soybean areas in disagreement with the SoyM and using the deforestation data from PRODES and ImazonGeo in the Amazonia portion found in the northern region of the State of Mato Grosso, which is the largest grain producer in Brazil.

2. MATERIAL AND METHODS

2.1. Study area

The study area comprised the Amazonia biome in the State of Mato Grosso, located between 09º00’ to 18º00’S and 49º00’ to 61º00’W (Figure1).

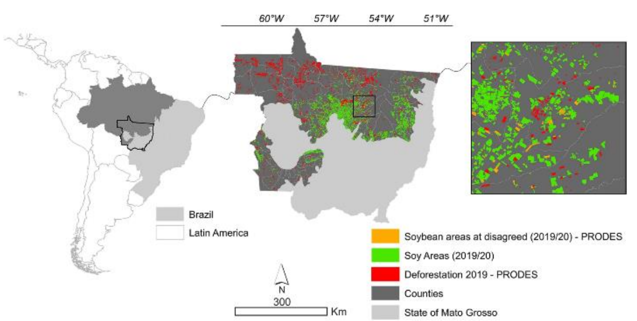

Figure 1. Study area comprising the Mato Grosso Amazonia biome.

2.2. Big data of spectral indices in soybean detection

For crop seasons from 2008/2009 to 2019/2020. A large amount of orbital data was used to perform the calculations of the PCEI index (Perpendicular Crop Enhancement Index) (Silva Junior et al. [3]). For this purpose, we used the MODIS

(Moderate Resolution Imaging Spectroradiometer), product MOD13Q1 V6 (MOD13Q1.006 Terra Vegetation Indices 16-Day Global 250 m – Image Collection ID MODIS/006/MOD13Q1 and sur_refl_b01 (Red surface reflectance, 645 nm) and sur_refl_b02 (NIR surface reflectance, 858 nm).

2.3. Deforested areas data

Regarding deforestation data, PRODES which provides annual deforestation estimates based on Landsat satellite images at 30 m resolution with a minimum mapped area of 6.25 hectares52,53 and SAD/ImazonGeo data that uses MODIS images at 250 m resolution to detect areas larger than 10 hectares with subsequent validation on Landsat (30 m pixel) and CBERS (20 m pixel) satellite images [5] were used to obtain the time series between August 2008 (Soy Moratorium agreement) until the year 2019.

2.4. Statistical analyses

Initially, boxplots were created to show the variation of the variables evaluated over the time series. The Mann–Kendall test was applied to verify the trend of the variables over the time series, followed by the Pettitt test to identify the likely point of change when the trend is significant. In all cases, a 5% probability level was adopted for the statistical tests performed.

3. RESULTS

All variables quantified with the ImazonGeo monitoring system presented a significant increase trend by the Mann–Kendall (M-K) test, i.e., there is a trend for increased deforestation over the years evaluated as well as an increase in polygons. The PRODES system also showed an upward trend for all variables except for the number of total polygons (TP), which considers polygons of soybean (PS), deforested areas towards soybean (DS) and total deforestation (TD). Pettitt (PTT) test identified the year 2013 as the likely point of change in the time series in cases of a trend to increase. The exception was the total deforestation variable quantified by the PRODES system, where no point of change was identified (Table 1).

Variable	Imazon			PRODES		
	M-K	PTT	Y	M-K	PTT	Y
T D	<0.00	0.03	2013	0.03	0.19	---
D S	<0.00	0.03	2013	<0.00	0.03	2013
T P	<0.00	0.03	2013	0.99	0.97	---
P S	<0.00	0.03	2013	<0.00	0.03	2013

Table 1. P-value of the Mann–Kendall and Pettitt tests for the variables total deforestation, deforestation for soybean planting, total polygons, and polygons for soybean planting obtained from the Imazon and PRODES monitoring systems.

Figure 2 shows the variation between variables over the time series as a function of the monitoring systems. It is possible to observe that the PRODES system presented higher variability in the data and statistically higher means than ImazonGeo in all cases.

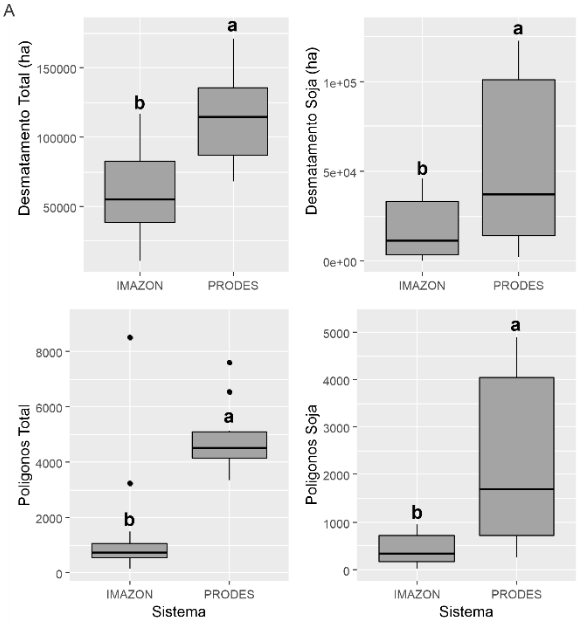

Figure 2. Boxplot for the variables total deforestation, deforestation for soybean planting, total polygons, and polygons for soybean planting obtained with the Imazon and PRODES monitoring systems.

According to the data obtained from PRODES, the accumulated deforestation from August 2008 to the end of 2019 was 1,387,288 hectares, and for the ImazonGeo data, it was 729,204 hectares. Thus, when comparing the two databases from the Sankey diagram (Figure 3), PRODES corresponded with the larger deforested area, with 66%, while ImazonGeo corresponded to 34%.

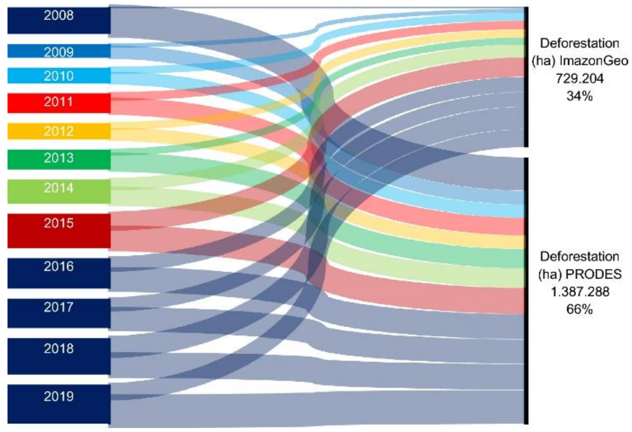

Figure 3. Sankey diagram showing, from the thickness of the lines and similar colors, the flows of deforestation variation over

the years for PRODES and ImazonGeo during August 2008 to October 2019.

According to the data obtained from the intersect between deforestation and soybean areas, it is evident that the conversion of forest to soybean areas has increased during the 2008/2009 to 2019/2020 crop seasons. In the total time series evaluated by PRODES, 108,411 ha were converted into soybean areas by the 2019/2020 crop season, representing 7.81%. By ImazonGeo, a total of 46,253 ha was transformed into soybean areas by the 2019/2020 season, representing 6.3%. The soybean areas accumulated over the time series in disagreement with SoyM for PRODES and ImazonGeo are shown in Figure. 4.

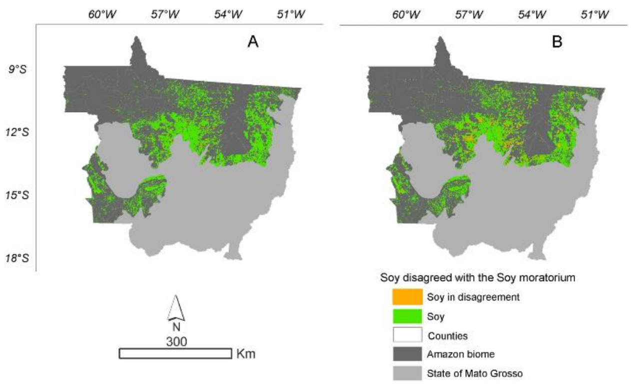

Figure 4. Accumulation of soybean planted in deforested area. (A) Soybean planted in deforested area according to ImazonGeo deforestation data. (B) Soybean planted in deforested area according to PRODES deforestation data.

The evolution of soybeans in disagreement with the SoyM in relation to the area planted with soybeans in the Mato Grosso Amazonia has increased during the crop years. In 2008/2009, it represented only 0.05% of deforestation converted into soybean areas, increasing to 2.51% of soybeans in disagreement with the SoyM in the 2019/2020 crop season, according to data obtained from the relationship between PRODES deforestation and soybean areas. The same happened with the relationship obtained with the deforestation data from ImazonGeo and areas of soybean cultivation. In the 2008/2009 crop season, there were 0.004% of soybean in disagreement with the SoyM and reaching 1.07% in the 2019/2020 crop season. The evolution represented by soybean areas in hectares makes it evident that the use of the MODIS/Terra-Aqua sensor underestimates the monitoring of cultivated areas, in which it can be seen from the 2016/2017 crop year monitoring with more refined spatial resolution and with the precise detection of areas via MSI (10 m) and OLI (30 m) sensors in Google Earth Engine. Currently, the soybean areas mapped and refined with the new sensors and that count as part of this study can be accessed on the website (https://pesquisa.unemat.br/gaaf/plataformas/).

Soybean in disagreement with SoyM over the years relative to deforested area to the entire time series went from 0.07% in 2008 to 7.81% in 2019 for PRODES deforestation, while for ImazonGeo evolved from 0.01% in 2008 to 6.34% in 2019.

4. DISCUSSION

The Pettitt test applied to the time series identified 2013 as the likely point of change in the evaluated time series. This finding corroborates studies carried out by INPE [6] which reported an increase in deforestation from 0.5 million ha in 2012 to 0.7 million ha in 2017. Environmental policies applied since 2000, such as the expansion of protected areas, creation of real-time monitoring program (DETER) and the SoyM were not sufficient to contain deforestation from 2013, which can be justified due to land grabbing and deforestation in rural settlements [7].

By evaluating time series for deforestation, Gollnow et al. [8] found that the year 2013 was a change point with increasing deforestation trends. The authors also highlight that direct deforestation for soybean crops decreased after the implementation of SoyM. However, indirect deforestation within the property increased and has accounted for more than half of the deforestation associated with soybean expansion since 2013. Another evidence for increased deforestation is that the SoyM does not punish farmers for deforestation on their farms that are not converted into soybean, which encourages deforestation for other uses [7].

Another related factor is the increase in the price appreciation of the soybean bag due to the global demand for food and biofuels [9]. In the 2019/2020 crop season, the soybean bag reached R$ 170.00 (US$ 31.40), similar to the fat cattle that reached R$ 171.50 in 2019 on the B3 (Official Brazilian Stock Exchange) [10]. These favorable market conditions and the lack of enforcement of illegal deforestation may justify the increasing rates of areas in disagreement with SoyM and de forestation by displacement on the property [1].

Most papers assessing deforestation in Amazonia and SoyM made use of PRODES data. Gibbs et al. [1], when evaluating SoyM in Brazil, used deforestation data provided by PRODES. By evaluating the soy moratorium in the 2016/2017 season in the State of Mato Grosso, Silva Junior & Lima [11] used deforestation data also provided by PRODES. Lima et al. [12], when identifying non-compliant soybean areas in Amazonian states, applied PRODES deforestation data. From this perspective, the scientific community considers PRODES to be the greatest tropical forest monitoring program, and it has been an effective tool for this purpose [13].

Few studies have been found referring to ImazonGeo, which is an important system in generating data that enables analysis by society, assisting in constructing and developing public policies [14]. In all cases, the PRODES system presented greater data variability and statistically higher means than ImazonGeo. PRODES stands out in providing the largest deforested area, with 66% of deforestation, while ImazonGeo provided 34%. Even if the same sensor system collects the data from both programs, the methodology applied is different, so it will not have the same values. According to Maretto et al. [15], the PRODES system depends on remote sensing experts to analyze the images from the sensor systems, which makes it an expensive and temporary task. Initiatives to automate image classification, as developed by Global Forest Watch and ImazonGeo, were carried out to minimize time and costs, but they were not as efficient as DETER and PRODES, which achieve accuracy of 90% in the classification [14].

The PRODES monitoring program was identified with the most expressive result in the SoyM evaluation compared to ImazonGeo. A total deforested area of 1,386,497 ha was identified in the Mato Grosso Amazonia from August 2008 to 2019 for PRODES, while ImazonGeo identified 729,204 ha. PRODES stood out with the largest deforested area at 66% and ImazonGeo with 34%.

5. CONCLUSIONS

Even with the differences regarding the results presented in this study, it can be noted that there is a small percentage of soybean occupying deforested areas compared to the total area of soybean planted in the Mato Grosso Amazonia, which was 2.54% (PRODES) and 1.07% (ImazonGeo) with an increasing trend throughout the evaluated time series. Regarding the deforested area to the total of the time series went from 0.07% in 2008 to 7.81% in 2019 for the PRODES, and for ImazonGeo evolved from 0.01% in 2008 to 6.34% in 2019. Although these rates are low, what draws attention is that they have not been maintained over the years but have had a trend towards increasing, resulting from the public policies of the past and current governments.

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