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# The fate of DETER Cerrado Alerts: Land Use and Land Cover associated with them in the Agricultural Frontier

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**ABSTRACT**. The primary aim of this study is to determine the predominant types of land use and cover that emerge in regions highlighted by DETER Cerrado alerts in the Oeste Baiano area from 2018 to 2020, utilizing data from Terraclass Cerrado 2020. The combination of DETER and TerraClass data provided valuable insights into the land use dynamics and the primary types of crops cultivated post-deforestation. The findings highlight significant trends and transformations driven by agricultural expansion, particularly in soybean and cotton cultivation. Although pasture is the most common land use following deforestation, particularly in São Desidério and Correntina, its establishment may be driven by the lower cost of cattle feed. A significant proportion of alerts transitioned to crop areas, demonstrating the region's agricultural dynamism. The municipalities also showed substantial increases in harvesting areas, indicating ongoing agricultural development. The results also imply that DETER plays a crucial role in mitigating the progression of clear-cut deforestation, evidenced by the significant presence of natural vegetation in certain regions.

**KEY-WORDS**: Oeste Baiano region; Deforestation; Cerrado; Environmental Surveillance.

## 1. INTRODUCTION

The region in the western part of Bahia, Brazil, has undergone significant Land Use and Land Cover (LULC) changes in recent decades (Santos; Sano, 2015). These changes are primarily driven by agricultural expansion, livestock farming, and infrastructural development, such as Irrigation Systems and Transportation Networks (Santos; Santo, 2023). Notably, in this region, part of the MATOPIBA (Maranhão, Tocantins, Piauí, and Bahia) agricultural frontier, has seen rapid growth in soybean farming due to favorable climate and soil conditions (Santos et al. 2011). As a result, large tracts of native Cerrado have been cleared leading to habitat loss, soil erosion, changes in water cycles, and loss of ecosystem services, posing risks to the biodiversity and the long-term sustainability of agricultural practices in the region.

Advances in methodology based on remote sensing have improved the monitoring of LULC changes in Oeste Baiano. These technologies enable the tracking of deforestation rates, land degradation, and changes in agricultural patterns (Pinheiro et al., 2023). Since 2018, the DETER Monitoring System (Near-Real-time Deforestation Detection) has been operating in the Cerrado delivering deforestation alerts in that Biome. DETER Cerrado was designed to deliver daily alerts on suppression in the natural vegetation cover, allowing for the timely implementation of environmental enforcement efforts. DETER Cerrado is based on the CBERS-4/WFI sensor (64 m spatial resolution) and AMAZONIA-1/WFI sensors (60 m).

TerraClass Cerrado is a project led by INPE and Embrapa that enhances Brazil's capacity to monitor its land use and land cover. The TerraClass project is an initiative focused on mapping land use and land cover, and it aims to provide detailed and updated information on the dynamics of land use and environmental changes within this critical Biome through the qualification of deforestation. The project uses Landsat (30m) and Sentinel (20m) satellite imagery to detect changes in land cover and land use (GEOPORTAL, 2024).

Combining DETER and TerraClass data can provide insights into the drivers and consequences of LULC changes in the region. These studies inform policy decisions and contribute to the developing sustainable land management practices. Oeste Baiano has experienced profound LULC changes primarily driven by agricultural expansion, which has brought both economic benefits and environmental challenges. Balancing the need for agricultural development with conservation and sustainable land management remains a critical issue for the region.

In this context, the main objective of this study is to identify the primary types of land use and cover that developed in areas flagged by DETER Cerrado alerts in the Oeste Baiano region between 2018 and 2020, based on Terraclass Cerrado 2020. Oeste Baiano has experienced profound LULC changes primarily driven by agricultural expansion, which has brought both economic benefits and environmental challenges. Balancing the need for agricultural development with conservation and sustainable land management remains a critical issue for the region.

## 2. METHODS

### 2.1 Study Area

This study was conducted in the West Mesoregion of Bahia, located in the Northeast Region of Brazil, specifically within the municipalities of São Desidério, Correntina, Riachão das Neves, Barreiras, and Luís Eduardo Magalhães (Figure 1). The climate, classified according to the Köppen and Geiger systems, is tropical, with a concentration of rainfall particularly during the summer (Carneiro, 2020).

The vegetation within these municipalities reflects the diverse ecological landscape of the Cerrado biome, characterized by a mosaic of different vegetation types, grasses, shrubs, and trees, shaped by both natural processes and human activities. In some areas, patches of seasonal forests featuring a mix of deciduous and semi-deciduous tree species adapted to the region's seasonal climate variations can be found. Some areas may exhibit transitional vegetation zones, where the Cerrado gradually transitions into other biome types, such as the Atlantic Forest or Caatinga, depending on factors like soil type, elevation, and rainfall patterns (INPE, 2021).

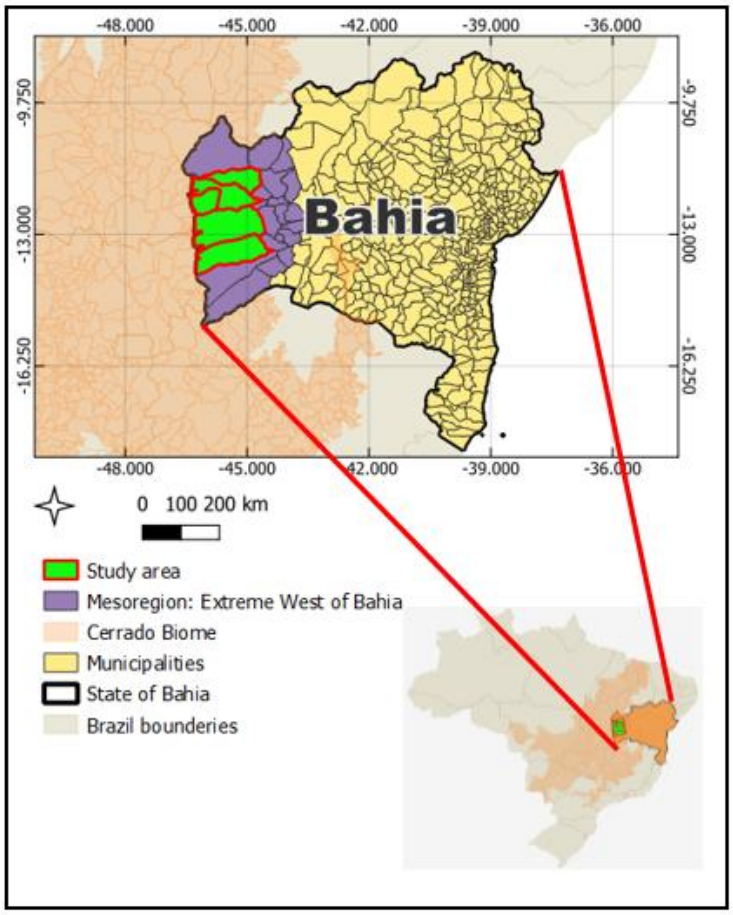


Figure 1 – The municipalities of São Desidério, Correntina, Riachão das Neves, Barreiras, and Luís Eduardo Magalhães representing the study area of Oeste Baiano, Brazil

## 2.2 Data analysis

Vector alert data from DETER Cerrado were acquired from the Terrabrasilis website, a platform developed by INPE for organizing, accessing, and utilizing geographic data generated by its environmental monitoring programs (ASSIS et al., 2019). We filtered the data specifically for the municipalities of São Desidério, Correntina, Riachão das Neves, Barreiras, and Luís Eduardo Magalhães, covering the period from 2018 to 2020 (INPE, 2020).

Annual periods used the reference dates of August 1 through July 31 to match the protocol used by PRODES Cerrado. PRODES is a project that estimates annual deforestation, and both DETER and TerraClass use PRODES data as a reference. DETER is based on a natural vegetation PRODES mask and aims to detect ongoing degradation/deforestation, while TerraClass is based on a PRODES mask and aims to classify land use and coverage in areas where natural vegetation has been removed, identifying and categorizing primary anthropogenic activities after human intervention..

Land use and coverage data for the year 2020 were sourced from the TerraClass Project (GEOPORTAL, 2024). Key mapped classes include secondary and primary natural vegetation, forest plantation, pasture, perennial crops, semi-perennial crops, temporary single-cycle crops, temporary multi-cycle crops, mining, urban areas, non-vegetated areas, other uses, and Annual deforestation for the year under analysis (details about the class can be found at https://www.terraclass.gov.br/geoportal-cerrado/). Next, we intersected the DETER Cerrado

alert layer and the TerraClass land use and coverage mapping layer, utilizing QGIS, a free and open-source geographical information system (QGIS DEVELOPMENT TEAM, 2024).

Data on the main economic activities in the municipalities of interest were retrieved through SIDRA – the Automatic Recovery System of the Brazilian Institute of Geography and Statistics (IBGE) (IBGE, 2024). This included calculating the agricultural area (in hectares and tons) and the number of cattle. This information was used to contextualize comparisons between DETER alerts and TerraClass data.

## 3. RESULTS AND DISCUSSIONS

Between 2018 and 2020, the DETER (Detection of Deforestation in Real Time) system reported approximately 1,000 km² of deforestation alerts in the Oeste Baiano region. Notably, the major warnings of these deforestation were concentrated in the municipality of São Desidério (Figure 2).

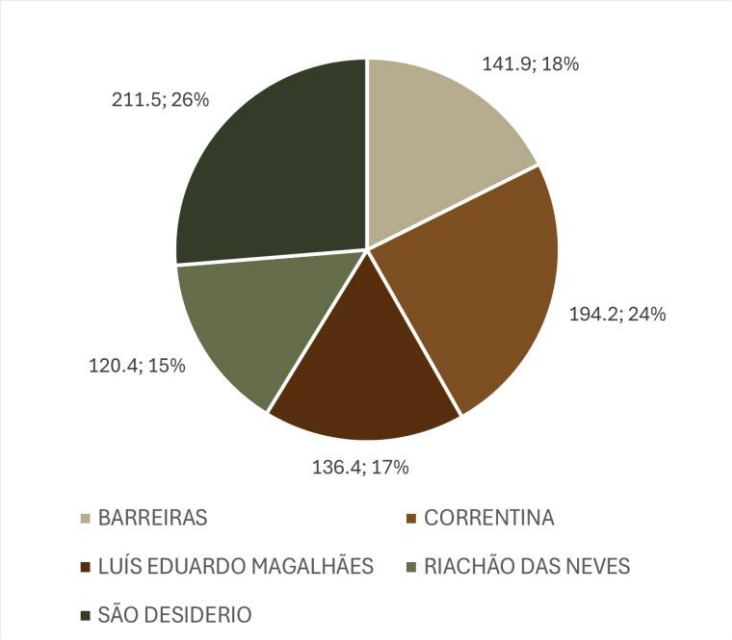


Figure 2 - DETER Deforestation Warnings Area (km²) detected in the Oeste Baiano Municipalities between 2018 and 2020

Based on the comparisons proposed in this article, we observed that, in general, alerts were confirmed as forest suppression by the PRODES project in the Oeste Baiano municipalities (Table 1). These results are consistent with those found by Pinheiro et al. (2023), which indicated that major suppression areas tend to be confirmed by PRODES or occur within a concentrated zone located 10 km from DETER Alerts. Nevertheless, a notable result in Table 1 is the significant proportion of natural vegetation, reaching 23% (49 km²) in São Desidério. This suggests that DETER is a useful tool in preventing the advance of deforestation.

Table 1 - Areas (Km²) of Deter Alerts classified as deforestation and Natural vegetation

| **Municipality** | **Deforested areas (Km²)** | **Natural vegetation (Km²)** | **Total (km²)** |
|---|---|---|---|
| Barreiras | 116.64 | 25.28 | 141.92 |
| São Desidério | 162.36 | 49.11 | 211.47 |
| Riachão das Neves | 106.31 | 28.36 | 134.67 |
| Luís Eduardo Magalhães | 117.67 | 18.75 | 136.41 |
| Correntina | 183.21 | 11.02 | 194.23 |

Figure 3 displays the Land Use and Land Cover map associated with the DETER Alerts. From Figure 4, pasture is the most frequent land use associated with alerts issued by DETER in São Desidério and Correntina municipalities. Typically, the deforestation process involves clear-cutting followed by the establishment of pastures. These pastures may remain as such, be abandoned, or eventually be replaced by modern agricultural practices. Pasture is established in the region because cattle feed is, on average, 15% cheaper due to the proximity to grain production areas (Oliveira; Vieira, 2018). Remarkably, Correntina displayed a 20% increase in its cattle herd, adding 25,000 animals between 2018 and 2020 (IBGE, 2024).

Correntina has the largest area abandoned after deforestation, while Luis Eduardo displays the lowest area. In other municipalities, the abandonment rate is, on average, 14% (Figure 3).

We found that in the cities of Riachão das Neves and Luís Eduardo Magalhães, 36.4% and 34.5% of alerts, respectively, became crops (perennial, semi-temporary, and temporary crops), showing the largest areas of crops within the alerts among the analyzed cities. According to the IBGE, between 2018 and 2020, Luís Eduardo Magalhães and Riachão das Neves showed an increase of 35.54 km² and 101.15 km², respectively, in areas dedicated to harvesting (IBGE, 2024). Soybeans are the predominant type of plantation in both municipalities due to the soil's great productive potential and high nutritional value (Oliveira et al., 2019; Santos and Santo, 2023). The area dedicated to soybeans remained stable, with a slight reduction between 2019 and 2020. However, cotton cultivation displays an increase of 34% (113 Km²) in planted areas, particularly in Riachão das Neves (IBGE).

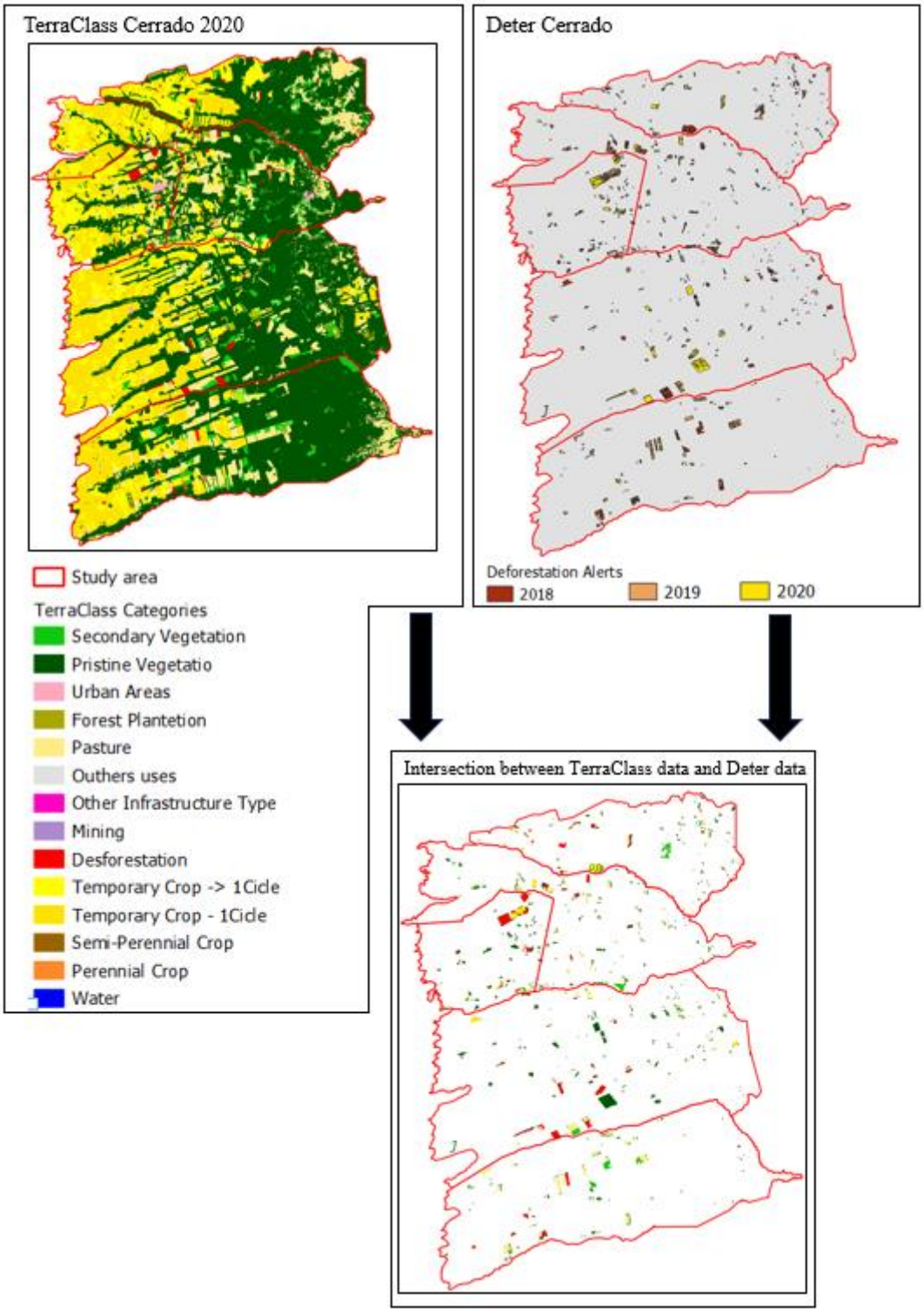


Figure 3 – Land Use and Land Cover classes associated with the DETER Alerts in the Oeste Baiano, Brazil

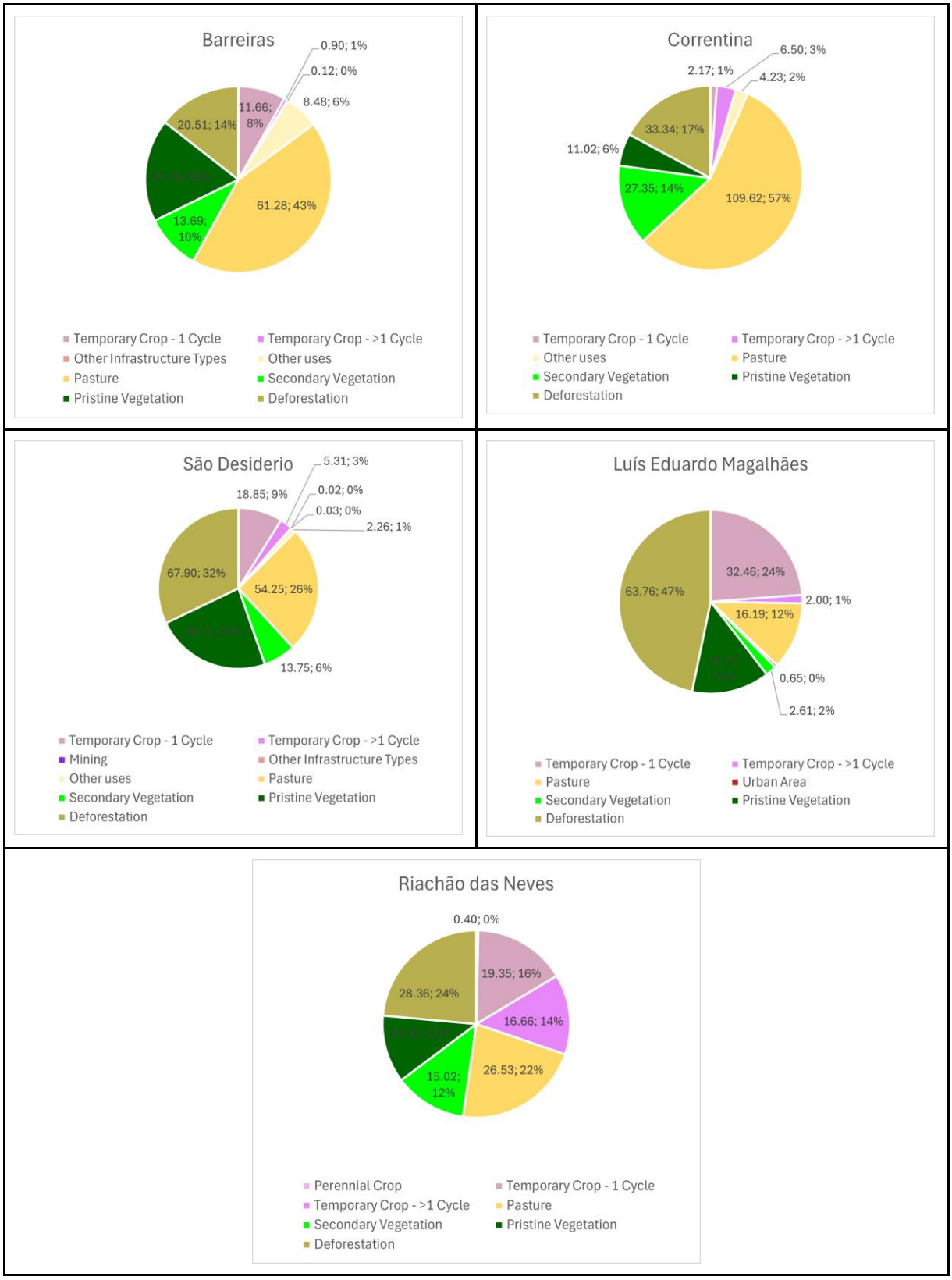


Figure 4 - Land Use and Land cover associated with Deter deforestation Alerts in the Oeste Baiano Municipalities

## 4. CONCLUSIONS

The integration of DETER alerts and TerraClass data facilitaded a comprehensive analysis of Land Use and Land Cover (LULC) changes in the Oeste Baiano region of Bahia, Brazil, between 2018 and 2020. Although pasture establishment is the most common land use following deforestation, particularly in São Desidério and Correntina, its prevalence is significantly influenced by the proximity to grain production areas. The findings highlight significant trends and transformations driven by agricultural expansion, particularly in soybean and cotton cultivation. Soybean remains the predominant crop in the region due to its high productive potential and nutritional value. While the area dedicated to soybean cultivation has remained relatively stable, cotton farming has experienced remarkable growth, particularly in Riachão das Neves. This expansion aligns with the broader agricultural trends observed in the MATOPIBA region.

The DETER alerts have proven effective in identifying agricultural expansion in the Oeste Baiano region. A significant proportion of DETER alerts corresponded to actual deforestation events, as validated by PRODES. The findings also suggest that DETER is instrumental in preventing the advance of deforestation, with a notable presence of natural vegetation in some areas.

The study underscores the dual nature of agricultural expansion in the Oeste Baiano region. While it brings economic benefits and contributes to the region's development, it also poses environmental challenges, including habitat loss and its related consequences, such as soil erosion and changes in water cycles. Balancing agricultural growth with sustainable land management practices remains crucial for the region's long-term ecological and economic health. Continued utilization and improvement of remote sensing technologies like DETER and TerraClass are essential for effectively monitoring LULC changes. These tools play a vital role in timely detection and intervention in deforestation activities.

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