CRESCIMENTO DA AGRICULTURA IRRIGADA POR PIVÔ CENTRAL NA BACIA HIDROGRÁFICA DO ALTO RIO DAS MORTES - MT

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1 RESUMO

O uso do solo e o seu tipo de cobertura tem sofrido modificações significativas nos últimos anos com o crescimento populacional e desenvolvimento da agricultura. Para obtenção de incrementos de produtividade agrícola uma das tecnologias mais empregadas no Brasil e no mundo é a irrigação. O objetivo dessa pesquisa foi identificar o número de equipamentos e as áreas equipadas com pivôs centrais na bacia hidrográfica do Alto Rio das Mortes no Estado de Mato Grosso, utilizando imagens de satélite de média resolução espacial. A bacia hidrográfica do Rio das Mortes está localizada no Centro-Oeste do Brasil, a qual está inserida na bacia do Rio Araguaia-Tocantins. Foram utilizadas imagens de satélite Landsat e a plataforma do Google Earth Engine (GEE). Foram construídas camadas de Índice de Vegetação por Diferença Normalizada (NDVI) e a partir desses dados procedeu-se a identificação e quantificação das áreas irrigadas por pivô central no local de estudo. Verificamos que a maior concentração de pivôs ocorre nas sub-bacias de Primavera do Leste (213 pivôs, 28 mil hectares) e Poxoréu (31 pivôs, 5 mil hectares). A bacia do Alto Rio das Mortes no ano de 2018 apresentava 271 pivôs centrais, ocupando uma área irrigada de aproximadamente 36,5 mil hectares.

Keywords: geotecnologias, índice de vegetação, irrigação, sensoriamento remoto.

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INCREASE IN CENTER PIVOT-IRRIGATED AGRICULTURE IN THE RIO DAS MORTES-MT RIVER BASIN**

2 ABSTRACT

Land use and land cover have changed significantly in recent years with population growth and the development of agriculture. To obtain increases in agricultural productivity, one of the most used technologies in Brazil and around the world is irrigation. This research identified the amount of equipment and areas equipped by center pivots in the Rio das Mortes River basin in the State of Mato Grosso, using satellite images of medium spatial resolution. The Rio das Mortes River basin is located in center-western Brazil, which is inserted in the Araguaia-Tocantins River basin. Landsat satellite images and the Google Earth Engine (GEE) platform were used. Normalized Difference Vegetation Index (NDVI) layers were constructed, and then the identification and quantification of the areas irrigated by center pivot in the study area were performed. The highest concentration of pivots in the Rio das Mortes River basin is in the sub-basins of Primavera do Leste (213 pivots, 28 thousand hectares) and Poxoréu (31 pivots, 5 thousand hectares). The Rio das Mortes River basin in 2018 had 271 center pivots, occupying an irrigated area of approximately 36.5 thousand hectares.

Keywords: geotechnologies, vegetation index, irrigation, remote sensing.

3 INTRODUCTION

Over the past three decades (between 1989 and 2019), Brazil's soil surface has undergone significant changes in vegetation cover. Tree-covered areas increased from 59.9% to 56.6%, whereas herbaceous crop areas increased from 14.6% to 17.7%; this, in absolute terms, represents significant changes in land use due to Brazil's continental size (ARRUDA et al., 2018).

From this perspective, in the state of Mato Grosso, where the Alto do Rio das Mortes River basin is located, the areas planted for grain production have increased considerably, with an emphasis on cotton, sunflower, corn and soybean crops (IBGE, 2017), which produces changes in the conditions of vegetation cover existing in the territory of the state and probably on the surface of the basin, caused by intense growth in agribusiness.

The state of Mato Grosso is the main producer of corn, soybeans, cotton, cowpea, sesame and sunflower in Brazil (IBGE, 2017). In this context of agricultural production, the Alto Rio das Mortes basin is one of the areas with the highest productivity of cotton and soybeans in the state of Mato Grosso.

On the other hand, over the course of six decades (1959--2019), there has been a considerable increase in the total irrigated area in Brazil, particularly in the Central-West region of the country. Similarly, when the annual increase (2000--2016) in mechanized irrigated areas was analyzed by system group, the most prevalent type of irrigation was the central pivot sprinkler irrigation system (ANA, 2017).

Research on the location of irrigation equipment is relevant and aims to contribute to better water management in river basins. From this perspective, the use of geoprocessing techniques and satellite imagery to survey areas irrigated by central pivots is a widely used technique with significant advantages in recognizing, estimating, and observing changes in these areas (MARTINS et al., 2016; TOLEDO; MORAES, 2018).

In particular, the use of satellite images stands out due to their versatility, current cost, time optimization, accessibility, global coverage, reduction in field visits, observation at various scales, immediate transmission, digital format, and

repetition of observations, among other advantages (CHUVIECO et al., 2018).

Notably, there are no updated surveys of the area occupied or the number of central pivots in the state of Mato Grosso, much less their distribution by river basin and municipality. Therefore, the objective of this study was to identify the number of central pivots and the areas equipped with central pivots in the Upper Rio das Mortes River basin in the state of Mato Grosso via medium-resolution satellite imagery.

4 MATERIALS AND METHODS

The Rio das Mortes basin is located in Central-West Brazil and is part of the Araguaia-Tocantins River basin. The basin area is approximately 61,000 km² and covers the state of Mato Grosso in the stretch between its source, in the Serra de São Vicente, municipality of Campo Verde - MT, to the mouth of the Araguaia River, in São Felix do Araguaia - MT, located in the quadrant formed by the coordinates 53°49'49" W 14°46'21" S and 55°24'42" W 15°52'03" S and with an altitude ranging from 510 to 913 meters.

The river basin is divided into two subbasins: upper and lower. In this study, the upper Rio das Mortes subbasin was selected. Figure 1 shows the basin selected for research development, along with its drainage network, subbasins, the municipalities involved, and their elevations. The natural vegetation cover of the area is classified as semideciduous seasonal forest, park savanna, forested savanna, or wooded savanna and belongs to the Cerrado Biome. The climate is Aw (ALVARES et al., 2013).

Figure 1. Location of the Upper Rio das Mortes basin, Mato Grosso State - Brazil
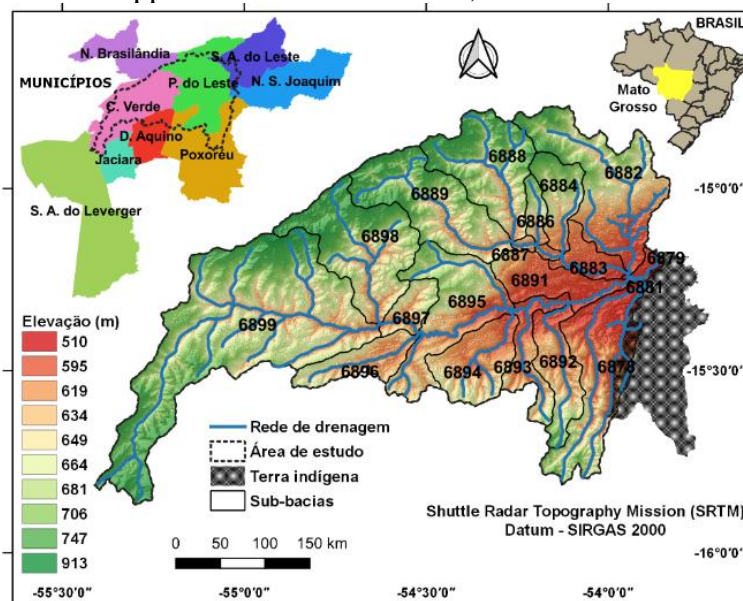
The primary sources of data and information for the development of the research were satellite images from the *Landsat project*, which consists of the longest historical series of teledetected earth observation data, which were obtained via a partnership between the National Aeronautics and Space Administration (*NASA*) and the United States Geological Survey (*USGS*), which is freely available on the internet at a horizontal spatial resolution of 30 m (WULDER et al., 2019; COSTA et al., 2020; JOSÉ et al., 2020).

The platform selected for processing satellite data and information was the *Google Earth Engine environment. (GEE). This environment is a* geospatial analysis system that uses cloud data with several petabytes of information obtained through remote sensing with global capacity and uses the *JavaScript programming language* to create algorithms for processing satellite images (KUMAR; MUTANGA, 2018).

Normalized difference vegetation index (NDVI) layers were constructed. The index is a measure of vegetation vigor and is determined from multispectral data as a normalized ratio between the red and near-infrared bands, ranging from minus one (-1) to one (1) (XUE; SU, 2017; COSTA et al., 2019). In this sense, monthly NDVI series from 1985--2018 were used for the study area in five periods, categorizing the land cover types into five classes for the dry and wet seasons in the defined periods.

The identification, quantification, and temporal analysis of the areas irrigated by central pivots were carried out through visual interpretation of the NDVI layers created in the previous phase via the free and open-source Geographic Information System *QGIS 3.6.2.* Circular and semicircular features were considered to identify the central pivot areas, and they were manually identified and vectorized via ellipse tracing tools.

5 RESULTS AND DISCUSSION

The spatial distribution maps of the NDVI in the study area, considering the average of the analyzed months for the years 1985, 1993, 2001, 2009, and 2018, are presented in Figure 2. As expected, the NDVI class limits are lower during the dry season than during the wet season. Between May and September, the study area is affected by water scarcity; several crops are viable only with supplemental water application during these months, although production can proceed normally during the rainy season (ANA, 2017). However, the images obtained during the dry season allow for accurate quantification of central pivot irrigation equipment, since during the rainy season, vegetated areas have a similar NDVI to irrigated crop areas (ALBUQUERQUE et al., 2020; TANG et al., 2021).

Figure 2. Spatiotemporal dynamics of the normalized difference vegetation index (NDVI) in the Rio das Mortes Basin-MT during the months of 1985, 1993, 2001, 2009 and 2018.
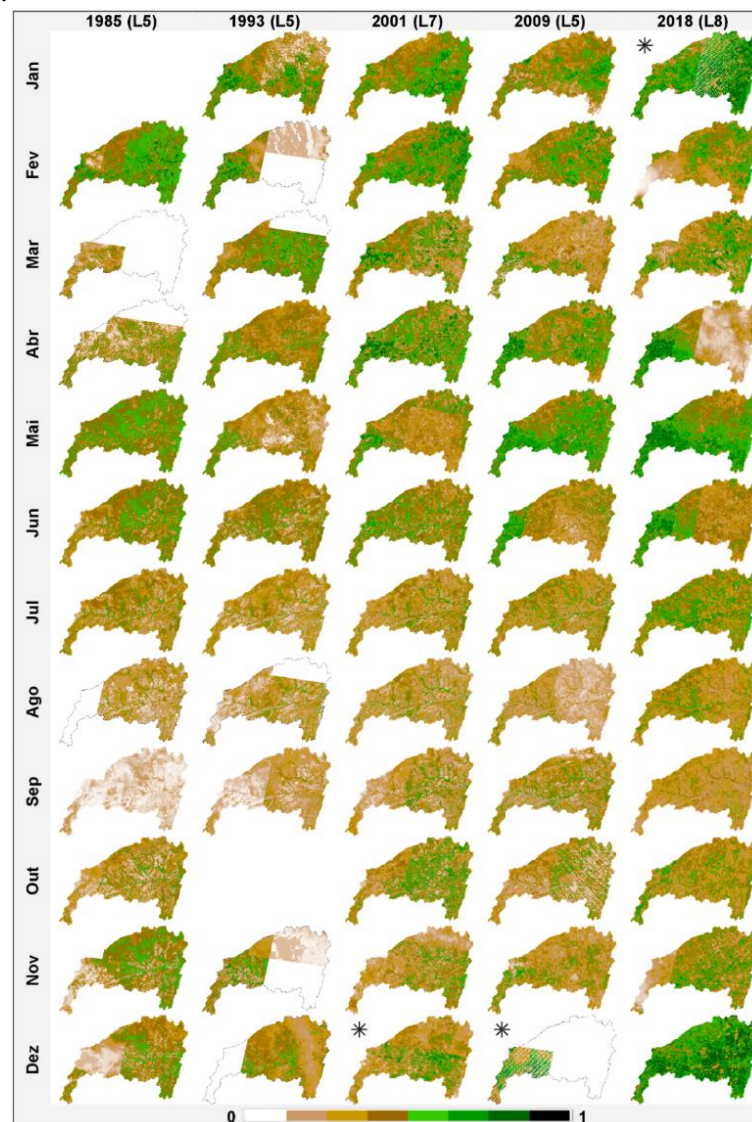

Figure 3 shows that when the densest NDVI classes of 0.7--1.0 and 0.4--0.7 were used as a reference, there was a general increase in the level of the NDVI contribution in the study area when past periods were compared with current periods. Schmidt et al. (2004) suggested that drought-susceptible conditions promote the use of irrigation. Furthermore, according to Pinheiro, Castro, and Guimarães (2006), the central region of Brazil has undergone changes in land use, for example, the growth of irrigated soybeans and corn. These factors could be what generated the largest changes in the NDVI values between the current and past periods in the Upper Rio das Mortes basin.

Figure 3. Contribution area of the normalized difference vegetation index (NDVI) categories in the Upper Rio das Mortes Basin during the dry and rainy periods over the last few years (1985--2018).
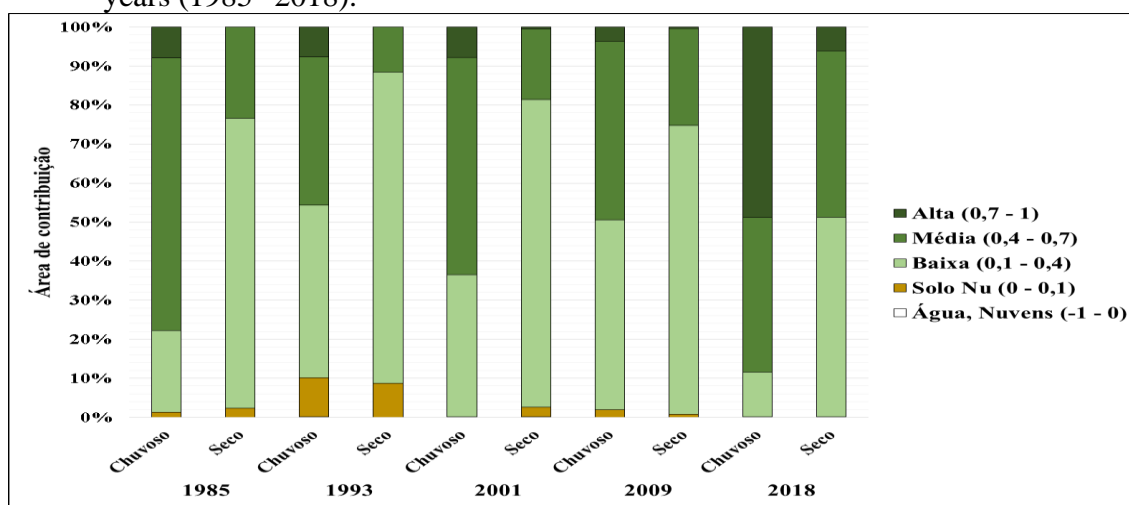

Table 1 presents the nine municipalities that constitute the Rio das Mortes watershed, with irrigated areas and numbers of central pivots. A total of 271 central pivots occupying an irrigated area of approximately 36.5 thousand hectares were quantified. The municipalities with the largest irrigated area were Primavera do Leste (213 pivots and 27,959.5 ha), Poxoréu (31 pivots and 4,959.5 ha), Campo Verde (19 pivots and 2,544.76 ha), Dom Aquino (7 pivots and 635.17 ha), and Santo Antônio do Leste (1 pivot and 161.57 ha).

In the municipalities of Jaciara, Nova Brasilândia, Novo São Joaquim, and Santo Antônio do Leveger, no central pivots were identified in the Upper Rio das Mortes basin. The results presented corroborate those reported by Demarqui and Demarqui (2020), who indicate that 76% of the central pivot irrigation equipment in the southeastern region of Mato Grosso is located in the municipality of Primavera do Leste, demonstrating that large rural properties have greater investment capacity.

Table 1. Number of central pivots, irrigated area (ha) and percentage of the area irrigated by central pivots (%) in the municipalities that cover the Rio das Mortes River basin in the state of Mato Grosso in 2018.

Municipalities	Number of pivots	Area irrigated by central pivot (ha)	Percentage of area irrigated by central pivot (%)
Green Field	19	2,544.76	0.51
Dom Aquino	07	635.17	0.28
Jaciara	-	-	-
New Brazilandia	-	-	-
New Saint Joaquim	-	-	-
Poxoréu	31	4,959.50	0.69
Eastern Spring	213	27,942.50	4.90
Saint Anthony of the East	01	161.57	0.04
Saint Anthony of Leveger	-	-	-

6 CONCLUSION

The use of medium spatial resolution satellite images allows the identification of the number of pieces of equipment and areas equipped with central pivots in a river basin.

The Alto Rio das Mortes River basin (State of Mato Grosso) in the 2018 agricultural year had 271 central pivots, occupying an irrigated area of approximately 36.5 thousand hectares.

This study provides concise data so that responsible government agencies and professionals in the area, together with rural producers, can improve the management of water resources in the Alto Rio das Mortes River basin (State of Mato Grosso).

7 ACKNOWLEDGMENTS

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