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ANÁLISE ESPAÇO-TEMPORAL DO ESPELHO D'ÁGUA DO AÇUDE TRUSSU ATRAVÉS DE SENSORIAMENTO REMOTO

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RESUMO: Devido a irregularidade das chuvas é de suma importância em regiões semiáridas o armazenamento e a distribuição de água para consumo e irrigação, devido a irregularidade das chuvas. O espelho d'água pode ser descrito como a superfície contínua exposta à atmosfera de corpos hídricos. Deste modo, objetivou-se, analisar a espacialização do espelho d'água do Açude Trussu, localizado no Ceará, através de imagens dos satélites Landsat 7 e 8, durante período de estiagem e comprovar correlação estatística entre o volume do reservatório e índices pluviométricos no período de 2011 a 2022. Utilizou-se o Índice de Água de Diferença Normalizada (NDWI) nas imagens para realçar os corpos hídricos. Para correlação estatística usou-se o método de Spearman, em que, para correlações envolvendo índices pluviométricos, considerou-se a variação de volume armazenado e do espelho d'água em relação ao ano anterior. Dos resultados obtidos, evidencia-se que entre 2011 e 2019 o reservatório teve uma variação de -1.749,99 hectares de espelho d'água. O espelho d'água está positivamente correlacionado com o volume armazenado (0,993), e ambos apresentaram correlação com os índices pluviométricos, 0,818 e 0,627 respectivamente.

Palavras-chaves: NDWI, estiagem, reservatório.

SPATIAL-TEMPORAL ANALYSIS OF THE WATER MIRROR OF TRUSSU DAM THROUGH REMOTE SENSING

ABSTRACT: The storage and distribution of water for consumption and irrigation are of paramount importance in semiarid regions due to the irregularity of rainfall. The water mirror can be described as the continuous surface exposed to the atmosphere of water bodies. Therefore, the aim of this study was to analyze the spatialization of the water mirror of the Trussu Dam, which is located in Ceará, using images from the Landsat 7 and 8 satellites during the dry season and to determine the statistical correlation between the volume of the reservoir and the rainfall indices for the period from 2011 to 2022. The normalized difference water index (NDWI) was used for the images in which the water bodies were highlighted. Spearman's method was used for statistical correlation. For correlations involving rainfall indices, the variation in the stored volume and water mass in relation to the previous year was considered. The results show that between 2011 and 2019, the reservoir had a water mirror area of -1,749.99 ha. The water mass is positively correlated with the stored volume (0.993), and both were correlated with the rainfall indices (0.818 and 0.627, respectively).

Keywords: NDWI, drought, reservoir.

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1 INTRODUCTION

Semiarid regions are generally characterized by climate irregularity, water scarcity, unpredictability of rainfall, long periods of drought and direct consequences for the economy and population (Dantas, 2017).

These characteristics directly influence the management of water resources. There is a need for methods that make water available for both agriculture and direct consumption. The construction of artificial barriers in watercourses resulted in artificial lakes (dams) that are used to meet the water needs of the northeastern population.

Therefore, monitoring the conditions of water storage reservoirs is extremely important. Water mirrors are, in the context of water resources management, the continuous water surfaces of a water body exposed to the atmosphere, corresponding, in general, to the area occupied by that body of water, be it a lake, pond, dam, dam reservoir, etc.

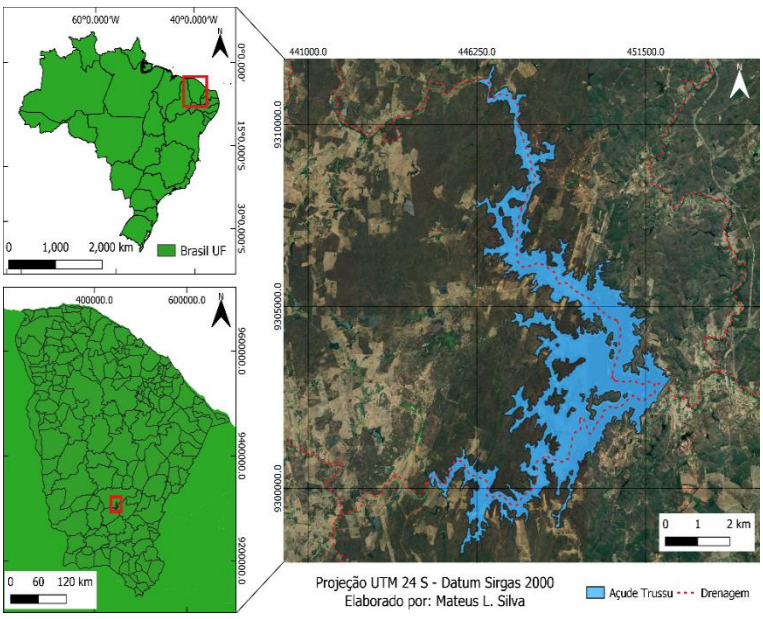
According to Verpoorter, Kutser and Tranvik (2012), as it is a surface visible from space, remote sensing through satellite images has been of great help in decision-making and monitoring the volume of reservoirs, and several authors have worked with this methodology to observe variations in the water surface (Barbosa et al., 2021; Sousa et al., 2022).

Thus, the present work aimed to analyze the variation in the water surface of the Trussu Reservoir in the state of CE between periods of drought and flood (2011 to 2022) based on satellite images, which were correlated with the volume obtained in the field and with the rainfall indices of the region.

2 MATERIALS AND METHODS

The analyzed reservoir (Figure 1), with coordinates of 6°17'12"S and 39°27'53"W, located in the city of Iguatu in the central-southern region of Ceará, was built on the bed of the Trussu River and has a capacity of 268,800,000 m3; this reservoir was named Açude Roberto Costa or is popularly known as Açude Trussu. The dam is located in a semiarid climate region.

Figure 1. Locations of the Trussu Dam, CE. Iguatu, Ceará.



Source: The author

The monitoring window was from 2011 to 2022, with images acquired in July, a period after the region's rainy season. The images used were obtained from Landsat 7 and Landsat 8

satellites through the United States Geological System (USGS). The images were subjected to the conversion process to TOA reflectance (top of atmosphere reflector) using the raster calculator of QGIS 3.28.3 software. The normalized difference water index (NDWI) was used according to Equation 1:

$$NDWI = \frac{Green-NIR}{Green+NIR} \quad (1)$$

where Green = the green wavelength (0.525 - 0.600 µm) and NIR = the near-infrared wavelength (0.845 - 0.885 µm). Landsat 7: Green = Band 2; NIR = Band 4; Landsat 8: Green = Band 3; NIR = Band 5.

The NDWI is used to highlight water features in a satellite image. To calculate the index, the reflectance of the soil and vegetation is considerably reduced, allowing the water mass to be more visible. After applying the index, the images were subjected to the reclassification process using the GRASS GIS r.reclass tool. For classification, NDWI values between 0.2 and 1 were identified as water, following the classification made by Özelkan (2020). The reclassified images went through the vectorization process, thus separating bodies of water from any other target that was not the object of study in this work. The volume data were obtained through the Ceará Hydrological Portal made available by COGERH (2023), which is from the same day, month and year as the images obtained.

The rainfall indices were acquired on the "Rain Calendar" platform on the FUNCEME website (2023), which refers to the months prior to the date of the images (January to June) in the Alto Jaguaribe hydrographic region. Correlations were calculated using the Spearman correlation test. For the rainfall data, only the variations in the water surface area (EDA) and volume in relation to the previous year were considered.

3 RESULTS AND DISCUSSION

Table 1 shows the variations in the water surface area, reservoir volume and rainfall in the region in the specified year. Between 2011 and 2019, the dam showed a decrease in the area of the water surface, as well as in volume, and it is also possible to observe that the rainfall levels during this period decreased. In 2011, when the reservoir reached its maximum volume, it rained 716.3 mm, and the following year, it rained 335.7 mm less, starting a period of drought in the reservoir.

Table 1. Volume, water surface of the Trussu Reservoir and rainfall in the Alto do Jaguaribe hydrographic region between January and June.

Period	Volume (%)	EDA (ha)	Rainfall (mm)
2011	100	2027.93	716.3
2012	89.89	1991.27	380.6
2013	69.96	1504.10	367.2
2014	52.76	1151.85	475.3
2015	32.72	929.30	420.4
2016	19.41	796.90	407.3
2017	11.38	597.76	415.5
2018	6.55	481.13	486.7
2019	1.85	277.94	537.1
2020	22.08	820.59	755.6
2021	28.60	849.14	545.2
2022	43.65	894.18	717.5

[1] Water mirror (EDA): Rainfall in the Alto Jaguaribe hydrographic region between January and June of the specified year.
Source: The author

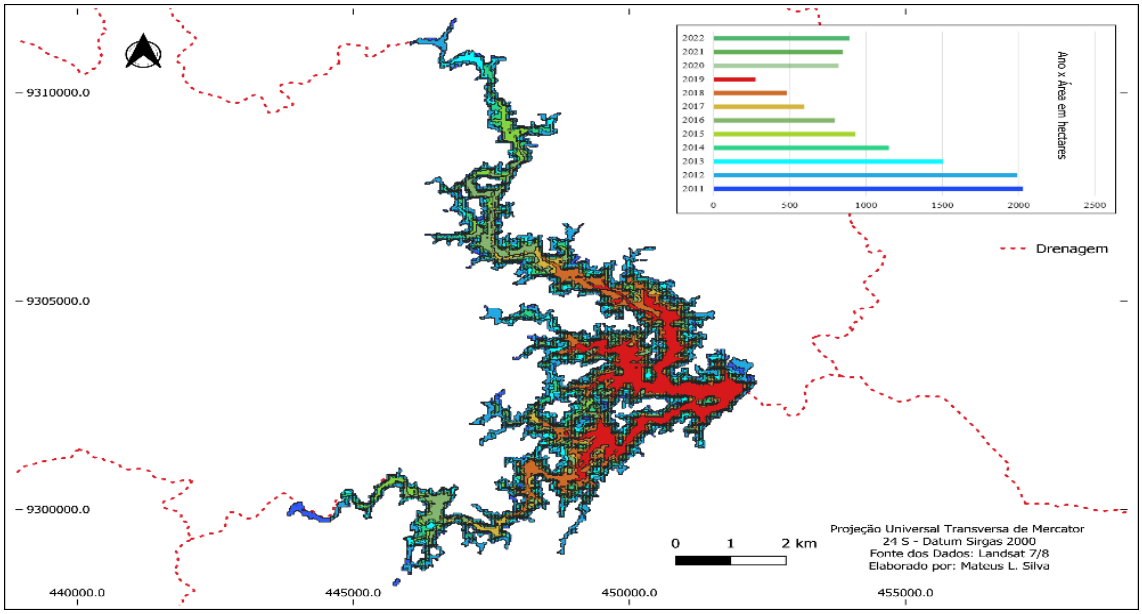
Statistically, the water surface area is positively correlated with the stored volume (0.993). Therefore, the stored volume directly influenced the spatial distribution of the water surface.

It was also proven that rainfall indices influenced the variation in volume and water surface area, where the correlation between precipitation and variation in stored volume presented a value of 0.818, indicating a strong correlation. The value between the EDA (water mirror) and precipitation was 0.627.

This statistically significant correlation was not detected in all reservoirs due to the topographic and consumption characteristics of each water body, as highlighted by Sousa et al. (2022) who were unable to correlate the variables in a dam in Ceará.

Figure 2 shows that from 2011 to 2019, the water surface area had a variation of -1,749.99 ha; however, after these 8 years of decline, in 2020, the reservoir area began to expand, with an increase in the volume of recurring rainfall and, in 2022, an increase of 616.24 hectares compared to that in 2019.

Figure 2. Variation in the water surface of the Trussu Reservoir between 2011 and 2022. Iguatu, Ceará.



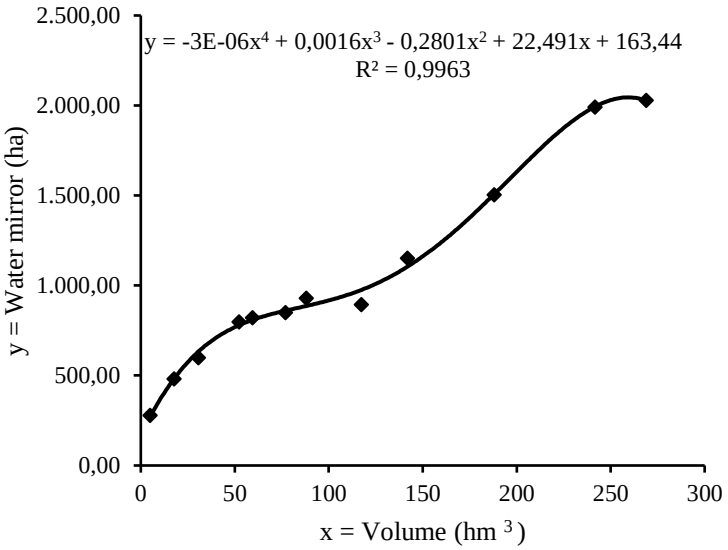
Source: The author

The space-time variations obtained are in line with those found by Silva et al. (2021), who studied these water mirror variations during drought years in the state of Ceará, showing that the Trussu Reservoir followed the trend of other reservoirs in the region.

Using the acquired data, it is possible to generate a trend line together with an equation that can measure the size of the water surface, with only the volume value in hand.

Figure 3 shows that R2 is 0.9963, demonstrating that the predictions closely approximate the real values. It is important to emphasize that this equation is only efficient for the reservoir mentioned in this work.

Figure 3. Variation in the water surface of the Trussu Dam, Ceará, as a function of volume variation and the corresponding polynomial equation. Iguatu, Ceará.



Source: The author

4 CONCLUSIONS

Satellite images, together with remote sensing techniques, were effective in monitoring the spatialization of the spatiotemporal dynamics of the water mirrors of the Trussu Reservoir.

This approach made it possible to create a trend line and a polynomial equation that aims to predict the water surface through volume.

Rainfall rates statistically influenced the volume and water surface of the Trussu Reservoir from 2011 to 2022.

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