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ENVIRONMENTAL CONDITIONS OF THE ELEMENTS OF A RURAL LANDSCAPE IN THE HIGHEST REGION OF THE TAQUARITINGA WATERSHED, SP, BRAZIL

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ABSTRACT

Most vulnerability identified in a watershed is due to anthropogenic interference in rural and urban areas. Sensitivity and common sense in joint action by the different agents of society can minimize the negative impacts on a basin through planned action. This study aimed to determine the environmental vulnerabilities of the highest region of the Taquaritinga watershed, SP, Brazil. The study methodology was the observation of satellite images using the free Google Earth Pro software by photocomparison of images in a sample area of 3,581 ha, divided into four quadrants. The results showed that the positive points of the area are the presence of straw on the ground and contour lines as conservation measures. However, it deserves special attention from the authorities to dispose properly of solid urban waste and the development of projects to re-establish native flora associated with the construction of more containment basins along the access roads to rural producers, which could contribute, in the long term, to improving the flow of water resources in the basin.

Keywords: Watershed; Environmental impact; Environmental vulnerability.

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INTRODUCTION

In any watershed, various positive or negative actions constantly occur, which can directly influence the impact degree to which the watershed is subject (Lanna, 2000; Almeida, 2010). A hydrographic basin is essentially characterized by a main watercourse fed by its tributaries, which, in the higher parts, is delimited by a watershed. Within this space, there are processes of runoff and sediment transportation (Sousa, Martins Filho, and Matias, 2012) that impact water quality and can lead to erosive processes, loss of agricultural productivity, reduction of permanent preservation areas, and silting of watercourses (Vischi Filho *et al*., 2016).

Each watershed can be subdivided into smaller watersheds, which means that a watershed is formed by a set of small watersheds (Rosa et al., 2004). A watershed is an area topographically defined by the drainage area of a river channel or by a system of connected river channels in a way that all the water draining into this space has a single direction of exit, information corroborated by geotechnologies (Pereira *et al*., 2017).

The vulnerabilities of a basin are generally the result of anthropogenic interference in rural and urban areas (Costa, 2018), and it is possible that such interference can be aggravated by the geomorphological conditions of a given region and intensified by the characteristics of the economic activities carried out by various segments of human activity, especially those that use natural resources (Candido *et al.,* 2010).

Almeida (2010) broadens the concept of vulnerability by reporting an enormous coincidence between social vulnerability in urban environments and regions where the population is exposed to higher risks, factors linked to urban sprawl (Jatobá, 2011), and soil sealing. It also points out that the risk areas with the greatest potential for impact are those of permanent preservation (APP) in urban environments.

The environmental assessment of a region allows identification of its potential for use (or non-use) of occupation, vulnerabilities, dynamics, and complexity of the ecosystem, leading to actions that enable its preservation and conservation (Vischi Filho *et al.*, 2016). Determining environmental vulnerability enables the assessment of the risk conditions of the area in question for geo-environmental processes such as erosion (**Figure 6**), soil contamination, water resources, and loss of agricultural use (Zonta, 2012; Vischi Filho *et al*., 2016). With proper planning, areas of environmental vulnerability in the watershed can be avoided by giving them uses compatible with their current state, in addition to carrying out studies to identify the factors that trigger this situation of environmental vulnerability and then seeking remediation alternatives (Cunha and Borba, 2014; Vischi Filho *et al*., 2016).

Geotechnologies have allowed studies to be performed on the environmental conditions of a river basin (Candido *et al.*, 2010). In this respect, Candido *et al.* (2010) studied the vulnerabilities of the Uberaba river basin in Minas Gerais and found that more than half of the basin area had degrees of severity, ranging from "accentuated to severe." In the analysis of the vegetation in the studied basin, the presence of very sparse vegetation cover was evident, denoting one of the marked vulnerabilities in the study, which are closely associated with negative anthropogenic actions, the result of soil degradation processes, and data that agrees with Zonta (2012) and Vischi Filho *et al.* (2016).

Geotechnology tools can be used to identify and map the geo-environmental characteristics and natural and environmental vulnerabilities of a given river basin and, through consistent public policies and orderly river basin management involving the various players in society, the ongoing process of vulnerability can be mitigated (Costa, 2018). In this study, Costa (2018) found that areas previously considered preserved have been making way for the growth of annual or perennial crops and short-cycle crops. These anthropogenic actions have significantly changed the local landscape due to inappropriate land use and conservation, easily observable from satellite images, even in areas close to urban centers, motivated by disordered urban sprawl. This study aimed to identify the environmental vulnerabilities of the highest region of the watershed in Taquaritinga, SP, Brazil, using the free Google Earth Pro software.

MATERIAL AND METHODS

The study was carried out in the region of Latitude 21° 22′ 12.94″S and Longitude 48° 26′ 29.97″O of the highest region of the Taquaritinga hydrographic basin, which belongs to the Tietê-Batalha Hydrographic Basin Council (CBH-TB) (**Figure 1**). A sampling area of approximately 3581ha was designated for the study (**Figures 2** and **3**) using the "line" tool in the "circle" tab of the free Google Earth Pro software (2021). The sample area of 3581ha was divided into four quadrants using the Google Earth Pro tools, according to the findings of Rodrigues, Bovério, and Ferrarezi (2020). **Figures 2** and **3** show the main study area highlighted in color and the elements of Quadrant 1.

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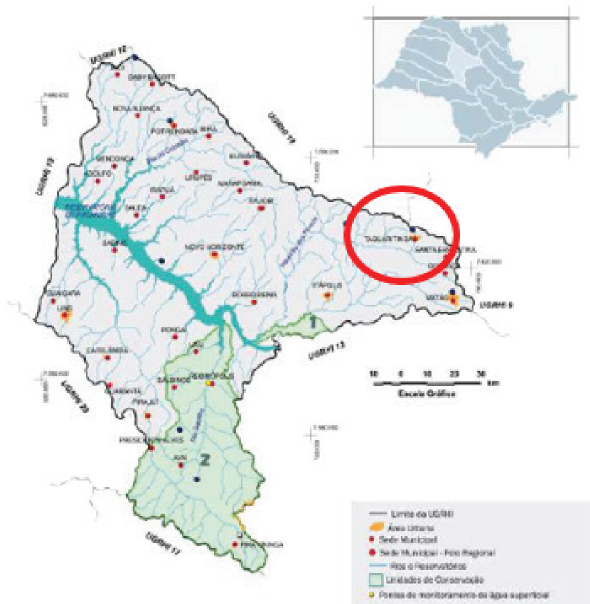

Figure 1. Map of URGHI 16 - Tietê-Batalha

Source: Technical Report on Water Resources Status (2020). The red circle indicates the boundaries of the municipality of Taquaritinga.

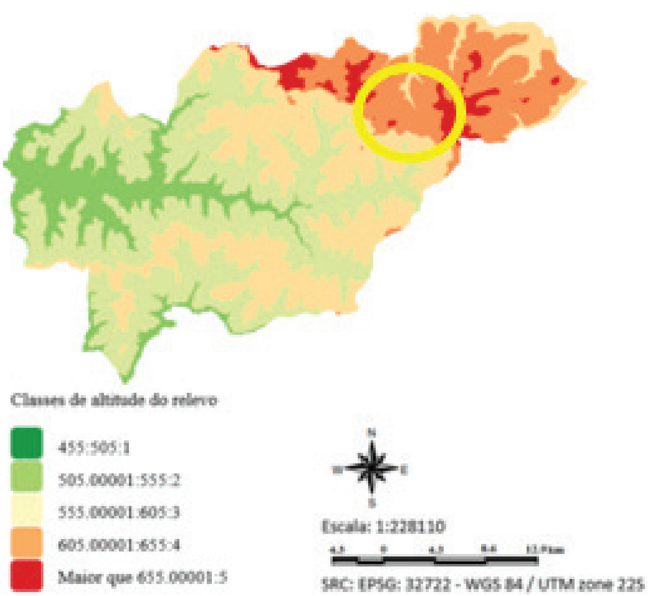

Figure 2. Hypsometric map using the soil elevation model of the municipality of Taquaritinga, SP.

Source: Adapted from Rodrigues, Carleto, and Santos (2020); using free software Qgis 3.0; using free software Qgis 3.6. The circle in yellow represents the study area.

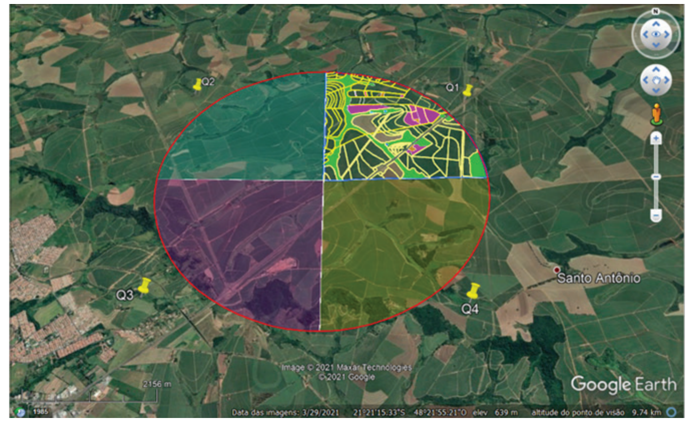

Figure 3. Sample area of the highest region of the Taquaritinga watershed, SP

Source: The authors, Google Earth Pro (March 2021); Q1, Q2, Q3, and Q4; Quadrants of the 3581 ha sampling area; Latitude 21° 22′ 12.94″ S and longitude 48° 26′ 29.97″ O

The elements of the rural landscape to be identified in the four quadrants consisted of the quantification of sugar cane haulers (CA), impermeable area (AI), represented by the asphalt network, permanent preservation area (APP), construction areas (AC), woody crop areas (CL), and water sheet areas (LD). The "polygon" tool was used to obtain information on the perimeter and area of each element in each quadrant. Semi-perennial crops (CSP), represented by sugar cane, were measured by subtracting the total area of each quadrant from the landscape elements present in the respective quadrant. The "path" tool was used specifically to measure the lengths of the path elements and the impermeable area, corresponding to the area covered by the asphalt road in the four quadrants (**Figure 4**). To calculate the area of paths (bare soil), the various types of paths in the quadrant were considered, varying in width. For this, ten widths of the tracks in each quadrant were sampled (at random) to obtain their average width, and the use of the total length of the tracks multiplied by their average width allowed us to estimate the probable area devoid of soil. The asphalting areas followed the same logic. Once the lengths of all the asphalted areas in the quadrant had been determined, the area resulted from multiplying the length by the width of the asphalt paving.

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Figure 4. Sample area of the highest region of the Taquaritinga watershed, SP. Quadrant 3 - highlighting the main elements of the landscape: APP areas (light green), woody crop areas (pink), rural construction areas (red), paths (yellow), institutional areas (gray), impermeable areas (black), and sugarcane cultivation areas (dark green)

Source: The authors, Google Earth Pro (May 2021)

The Permanent Preservation Areas (PPA), Construction Areas (CA), Woody Crop Areas (CL), and Water Sheet Areas (WLA) had their perimeter and area directly determined using the "polygon" tool. Semi-perennial crops (CSP), represented by sugar cane, were determined by subtracting the total quadrant area and all the elements of the rural landscape. The construction areas were considered the clear images of houses or masonry sheds and part of a contour, sometimes made up of pastures, sometimes composed of various fruit trees or native species, and finally, degraded areas.

Excel software was used to organize the data in the case of data measured in hectares when corresponding to the area and to calculate the percentages of each landscape element compared to the total quadrant area. For the data's statistical analysis, the quadrants were considered repetitions, and the treatments were only those with repetitions greater than or equal to four evaluations in each quadrant. In this case, only APP areas, paths, and sugarcane crop areas (plots) could be statistically analyzed. The other elements could only be ascertained. A completely randomized design (CRD) with four replications was used for the analysis of variance using the Fisher-Snedecor F test, and for the test of means, the Scott Knott test was used. Both tests were performed at 11% probability using the free software Sisvar, version 5.6, by Ferreira (2008).

RESULTS AND DISCUSSION

The results of the analysis of variance of the landscape elements that stood out most in the visualizations during the study showed that there was no significant effect of the size of the sugarcane fields (CSP), the length of the sugarcane tracks, or the permanent preservation areas (APP) at the 11% probability level (**Table 1**). The test of means showed a significant difference ($P < 0.11$) only in the size of the sugar cane plots. The results of the quantification of the elements of the rural landscape that can be quantified or visually identified are shown in **Graph 1**. The four most significant elements in the landscape are sugar cane crops (75%), followed by permanent preservation areas (APP = 15.1%), woody crops (3.1%), paths (CA = 3.96%), construction areas (AC = 1.12%), paved (impermeable) areas (AP = 0.76%), institutional areas (AI = 0.42%), and water slides (0.06%), totaling 3581ha. Since the total area of this study corresponds to 3581ha, according to the new forestry code, the areas set aside for legal reserves (RL) should correspond to almost 20% of the quadrant's area, i.e., 716.2ha.

Table 1. Summary of the analysis of variance of the effects of the size of the plots, the length of the paths, and the size of the permanent preservation areas of the sampling area in the highest region of the Taquaritinga watershed, SP

Analysis of variance regarding the size of sugarcane plots					
FV	GL	QM	Fc	Pr > Fc	
Treatment	3	105.601	2.776	0.103*	
Residue	3	47.959	1.261	0.345	
Residue	9	38.04			
CV (%)	Sugarcane plot mean test				Overall Average
32.55	Q1**	Q2	Q3	Q4	18.95 ha
	14.06b	19.55b	16.30b	25.87a	
Analysis of variance for the length of sugar cane tracks					
FV	GL	QM	Fc	Pr > Fc	
Treatment	3	0.295	0.343	0.79ns	
Residue	3	2.394	2.776	0.10	
Residue	9	2.587			
CV (%)	Mean test for sugarcane tracks				Overall Average
40,71	Q1**	Q2	Q3	Q4	1.31 km
	1.18a	1.19a	1.38a	1.50a	

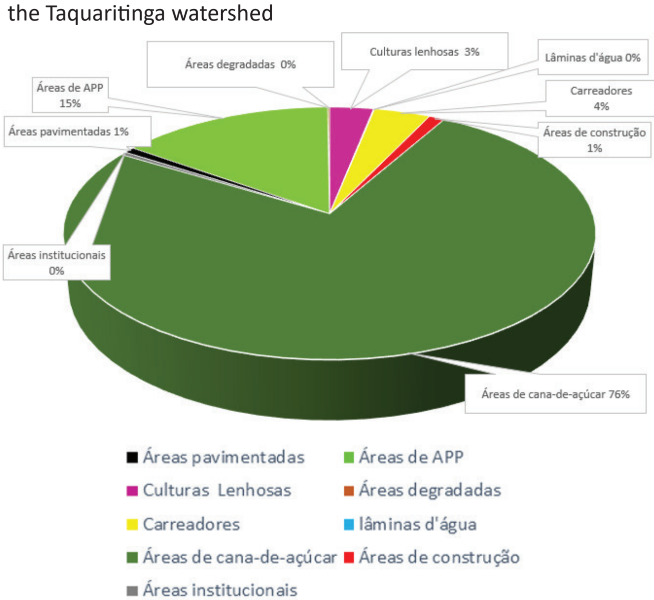
Analysis of variance for Permanent Preservation Areas					
FV	GL	QM	Fc	Pr > Fc	
Treatment	3	151.08	0.548	0.661ns	
Residue	3	2234.60	8.110	0.006	
CV (%)	Test of means for Permanent Preservation Areas				Overall Average
50.33	Q1**	Q2	Q3	Q4	32.98ha
	24.22a	33.25a	36.70a	37.75a	

* It indicates that the test was significant at the 11% probability level; ns: it indicates that the test was not significant.

** Equal lowercase letters on the same line indicate that the test was not significant at the 11% probability level.

The existence of significant areas of legal reserve (LR) in the four quadrants was not clearly identified, occurring in part in the southern region of quadrants 3 and 4 due to the layout, the sampling area inserting part of the hillside area of the Serra de Jaboticabal. Observing the study area, it can be seen that the areas of sufficient environmental fragility correspond to the areas surrounding the controlled landfill in Quadrant 3 (**Figure 5**), which has significant potential for contaminating the water table (Gouveia and Prado, 2010; Giacomazzo and Almeida, 2020) in the short term and the Bauru aquifer in the longer term, due to leachate percolation.

Graph 1. Elements of the rural landscape in the highest region of the Taquaritinga watershed



Source: The authors, Google Earth Pro (May 2021)

It can also be seen that the waterproofing area is present in all four quadrants, represented by the asphalt of two highways, one linking Taquaritinga to Jaboticabal, SP, and the other linking Taquaritinga to Monte Alto, SP. The road edges linking Taquaritinga to Jaboticabal are formed by dual carriageways with properly maintained embankments and internal rainwater drainage channels between the two carriageways. In addition, it is easy to see the construction of rainwater containment basins (**Figure 5**) on the side of one of the lanes, which is a positive measure for conserving water resources. The study area is still well endowed with contour lines (**Figure 5**) and the presence of straw on the ground due to the mechanized harvesting of sugar cane, especially in Quadrants 3 and 4, which is a highly recommended practice that can mitigate any degree of erodibility of a given region or even prevent erosion by rain, which can place the watershed in a degree of environmental fragility (Santiago *et al.*, 2019). **Figure 6** shows an area in an advanced process of erodibility, showing the greater environmental frangibility of quadrant 4. In this study, the presence of straw shown by the satellite images can be inferred as a very positive aspect for mitigating possible losses of soil and organic matter, contributing to the sustainability of the agricultural production system (Sousa, Martins Filho, and Matias, 2012).

Figure 5. Highlighting the main landscape elements in Quadrant 3; The larger red outline represents the controlled landfill in Taquaritinga, SP. In a smaller red outline, there are rainwater containment basins. Source: Google Earth Pro (May 2021)

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Figure 6. A highlight of a landscape element in quadrant 4. The red outline represents a single degraded area in the sample area. Source: Google Earth Pro (May 2021). Artificial and natural water depths are rare in the APP areas of the study area.

These elements of the landscape have the natural function of conserving the ecosystem as they enrich the habitat, which can be better exploited by wild animals for watering; however, their banks and interiors are contaminated by grasses. In addition, it is perfectly observable that there are native plants, but they are very sparse, denoting a source of food and shelter for wild animals in precarious conditions. These vulnerabilities agree with the vulnerabilities of a watershed reported by Candido et al. (2010) in the region of Uberaba, MG, and in the studies by Almeida (2010).

It is possible that the factors triggering environmental vulnerability in the studied basin could be reversed in the medium and long term by seeking alternative remedies (Cunha, Ritter, and Borba, 2014). According to Costa (2018), consistent public policies and the orderly management of river basins can mitigate the ongoing process of vulnerability as long as they involve various agents (Castro, 2012), including rural producers, public extension agents or not, the river basin committee, the municipal government, and the sugar-alcohol sector operating in the river basin. Therefore, it is essential to adopt geotechnologies to respond faster and with greater quality to the growing and diverse demands of public policies (Guia *et al*., 2016).

Soil and water conservation management practices (containment basins, contour lines, and straw on the ground), cited by Tucci (2005), if implemented in a given basin, allow positive changes to the landscape and positively influence agricultural yields. Satellite images can prove different changes to the landscape through photocomparison, a feasible methodology for monitoring, and even agri-environmental rehabilitation for managing micro-watersheds (Vichi Filho *et al.*, 2016).

CONCLUSION

The main vulnerabilities detected in the region under study concern the environmental protection areas, the legal reserve proportional to the studied area, which is probably out of step with the legislation. The permanent preservation areas are contaminated with various forage grasses, there are few native woody plants, and surface watercourses are not apparent. The area under study also presents risks of contamination of the water table and the Bauru aquifer due to the presence of a controlled landfill. The overgrowth of sugarcane areas, divided by tracks, results in a considerable area of bare soil. The positive points of the area in question are the presence of straw on the ground, contour lines, and containment basins; however, they are few in number as conservation measures, but the area under study indicates that attention should be paid to developing projects to re-establish native plants associated with the construction of more containment basins, which could contribute in the long term to improving the flow of the basin's water resources.

REFERENCES

Almeida, L.Q. de (2010), *Vulnerabilidades socioambientais de rios urbanos: bacia hidrográfica do rio Maranguapinho, região metropolitana de Fortaleza, Ceará*, Tese de doutorado, Universidade Estadual Paulista, Instituto de Geociências e Ciências Exatas-Rio Claro, 278p.

Candido, H.G., Galbiatti, J.A., Pissarra, T.C.T. & Martins Filho, M.V. (2010) Degradação ambiental da bacia hidrográfica do rio Uberaba: uma abordagem metodológica, *Revista Engenharia Agrícola*, v.30, n.1, pp. 179 – 192.

Castro, J.E. (2012), "A gestão da água na América Latina", *Revista Desafios do desenvolvimento***, ano 9, 74 ed.**

Comitê da bacia hidrográfica do Tietê batalha (2019), *Relatório de Situação 2020 – ano base 2019*, Secretaria Executiva do CBH-TB, disponível em: https://www.comitetb.sp.gov.br/documentos/ (acesso em: 03 junho 2022)

Costa, F.R. da (2018), Análise da Vulnerabilidade Ambiental da Bacia Hidrográfica do Rio Doce (RN), Tese de Doutorado em Desenvolvimento e Meio Ambiente, Centro de Biociências, Universidade Federal do Rio Grande do Norte, Natal.

Cunha, P.D. da, Ritter, L.G. & Borba, W.F. de (2014), "Vulnerabilidade ambiental e áreas de infiltração máxima de água", *Revista Monografias Ambientais*, vol. 13, no. 5, pp. 3761 – 3776.

Ferreira D.F. (2008), "SISVAR, versão 5.6: um programa para análises e ensino de estatística", *Revista Científica Symposium*, vol. 6, no. 2, pp. 36–41, disponível em: https://des.ufla.br/~danielff/programas/sisvar.html

Giacomazzo, A. P. & Almeida, W. S. de (2020), "Estudo do potencial de contaminação do Aterro Controlado do Jóquei Clube, D. F. Eng. Sanit. Ambient, v.25 n.6, nov/dez,909 – 920

Gouveia, N. & Prado, R.R. do (2010), "Riscos à saúde em áreas próximas a aterros de resíduos sólidos urbanos", Revista de Saúde Pública, vol. 44, no. 5, pp. 859 – 66

Guia, G. A. da, Mattos, H., Buzar Neto, J. & Vieira, E. (2016), "Geotecnologias na administração pública", *Revista Desafios do desenvolvimento***, ano** 13, 87 ed.

Jatobá, S. U. S. (2011) Urbanização, meio ambiente e vulnerabilidade social. IPEA, boletim regional, urbano e ambiental, 05, jun., p. 141 – 148.

Lanna, A. E. A (1997), "Inserção da Gestão das Águas na Gestão Ambiental (2000)", in Muñoz, H.R., *Interfaces da Gestão* *de Recursos Hídricos Desafios da Lei de Águas*, 2 ed., Ministério do Meio Ambiente, pp. 77 – 109.

Pereira *et al*. (2017), "Caracterização de uma bacia hidrográfica utilizando ferramentas de geoprocessamento", artigo apresentado no IX Simpósio Brasileiro de Engenharia Ambiental, XV Encontro Nacional de Estudantes de Engenharia Ambiental e III Fórum Latino-Americano de Engenharia e Sustentabilidade, Belo horizonte, MG.

Rodrigues, G. A., Carleto, N. & Santos, G.O (2020), "Geração um de mapa hipsométrico da bacia hidrográfica de Taquaritinga-SP", *Interface Tecnológica*, vol. 17, no. 1, pp. 492-504, disponível em: https://revista.fatectq.edu.br/interfacetecnologica/article/view/824/487, DOI: https://doi.org/10.31510/infa.v17i1.824

Rodrigues, G. A., Ferrarezi, L. A. & Bovério, M. A. (2020), "Metodologia para determinação da abundância de árvores urbanas utilizando recursos de geotecnologias de acesso livre", *Journal of Biotechnology and Biodiversity*, vol. 8, no. 3, pp. 172–178, DOI: https://doi.org/10.20873/jbb.uft.cemaf.v8n3.rodrigues

Rosa *et al*. (2004), "Elaboração de uma base cartográfica e criação de um banco de dados georreferenciados da Bacia do Rio Araguari — MG", in Lima, S. do C. & Santos, R.J. (Org.), *Gestão Ambiental da bacia do Rio Araguari — rumo ao desenvolvimento sustentável*, Editora UFU/CNPq, Uberlândia, 221 p.

Santiago, C.M.C., Sales, M.C.L.; Silva, E.V. da & Paula, J.E. de A. Diagnóstico físico conservacionista da bacia hidrográfica do rio São Nicolau-Piauí, artigo apresentado no XVIII Simpósio Brasileiro de Geografia Aplicada, Universidade Federal do Ceará, Fortaleza, Ceará, 11-15 jun. 2019.

Sousa, G. B., Martins Filho, M. V. & Matias, S. S. R. (2012), "Perdas de solo, matéria orgânica e nutrientes por erosão hídrica em uma vertente coberta com diferentes quantidades de palha de cana-de-açúcar em Guariba — SP", Revista de Engenharia Agrícola, vol. 32, no. 3, pp.490 – 500.

Tucci, C.E. M. (2005), *Gestão de Águas Pluviais Urbanas*, Ministério das Cidades, Global Water Partnership, Wolrd Bank, Unesco.

Vischi Filho *et al*. (2016), "Diagnóstico e reabilitação agroambiental de trecho de bacia hidrográfica por sensoriamento remoto e turbidez da água", *Pesquisa Agropecuária Brasileira*, vol. 51, no. 9, pp. 1099 – 1109, DOI: https://doi.org/10.1590/S0100-204X2016000900009

Zonta, J.H. (2012), Circular Técnica 133, *Práticas de conservação de solo e água*, Embrapa-Algodão, Campina Grande, PB, setembro, 21 p.

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