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MAIN ENVIRONMENTAL VULNERABILITIES FOUND IN A RURAL LANDSCAPE USING GEOTECHNOLOGIES

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Abstract: The identification of vulnerabilities in a watershed is largely the result of human interference in rural and urban areas. In joint action, the responsibility and common sense of the different agents of society can minimize the negative impacts on a basin through a planned action. The objective of this study was to determine the environmental vulnerabilities of the highest region of the Taquaritinga watershed, SP, Brazil. The methodology of the study was the observation of satellite images using the free software Google Earth Pro, through photocomparison of images in a sample area of 3581 ha, divided into four quadrants. The results showed that the area presents as positive points the presence of straw on the soil and contour lines as conservation measures. However, it deserves special attention from the authorities to properly dispose of urban solid waste, as well as the development of projects to restore native flora associated with the construction of more containment basins, along the access roads to rural producers, which can contribute in the long term to improve the flow of water resources in the basin.
Keywords: Environmental impact; environmental vulnerability; hydrographic basin.

INTRODUCTION

In any hydrographic basin there are several positive or negative actions, which happen all the time, and that can directly influence the degree of impact to which this basin may be subject (LANNA, 2000; ALMEIDA, 2010). A hydrographic basin is characterized essentially by a main watercourse, which receives the insertion of its tributaries, and which in the higher parts is delimited by a watershed, and within this space, flow processes, sediment transport occur (SOUSA, MARTINS FILHO eMATIAS, 2012), which impact water quality, can induce erosion processes, agricultural productivity losses, reduction of permanent preservation areas and silting of water courses (VISCHI FILHO et al., 2016).

Each hydrographic basin can be subdivided into smaller basins, which means that a hydrographic basin is formed by a set of small basins (ROSA et al., 2004). A watershed is an area topographically defined by a drainage area of a river channel or by a system of connected river channels, in such a way that all water drained in that space has a single exit direction, information that is corroborated by the use of geotechnologies (PEREIRA et al., 2017).

The vulnerabilities of a basin are largely the result of human 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 activities, especially those that use natural resources (CANDIDO et al., 2010).

Almeida (2010), expands the concept of vulnerability, where he reports the existence and a very great coincidence between social vulnerability in urban environments and in regions where the population is exposed to greater risks to factors linked to urban expansion (JATOBÁ, 2011) and the soil waterproofing. It also addresses that the most common risk areas to be impacted are permanent preservation areas (APP) in urban environments.

The environmental assessment of a region allows the 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). The determination of environmental vulnerability makes it possible to assess the risk conditions of the area in question to geoenvironmental processes such as erosion, contamination of soils, water resources, loss of agricultural use, among others (ZONTA, 2012; VISCHI FILHO et al., 2016). Based on adequate planning, areas of environmental vulnerability within the watershed can be avoided, giving them uses compatible with their current state, in addition to carrying out studies in order to identify the factors that are triggering this situation of environmental vulnerability, for then seek remediation alternatives (CUNHA eBORBA, 2014; VISCHI FILHO et al., 2016).

The use of geotechnologies has allowed conscious studies on the environmental conditions of a watershed (CANDIDO et al., 2010; FREITAS, KLOSS and Da SILVA, 2012; COSTA, SOUZA and SILVA, 2021). In this aspect, Candido et al. (2010) studied the vulnerabilities of the Uberaba river basin, in MG, and found that more than half of the basin area had degrees of severity ranging from "severe to severe". In the analysis of the vegetation of the basin of the study, the presence of very sparse vegetation cover was evident, which denotes one of the remarkable vulnerabilities in the study, which are closely associated with negative anthropic actions, as a result of soil degradation processes, data that agree with ZONTA (2012) and VISCHI FILHO et al.(2016).

The use of geotechnological tools makes it possible to identify and map the geoenvironmental characteristics and the natural and environmental vulnerabilities of a given watershed, and through consistent public policies, and the orderly management of watersheds involving the various actors of society, it is possible to mitigate the ongoing vulnerability process (COSTA, 2018). In this study, COSTA (2018) found that areas that were previously considered preserved have allowed space for the growth of annual or perennial crops, and even short-cycle crops, in such a way that such anthropic actions, through the use and conservation of the soil in a inappropriate, significantly changed the local landscape, which is easily observable by satellite images, even in areas close to urban centers, motivated by disorderly urban sprawl. The objective of this study was to determine the environmental vulnerabilities of the highest region of the Taquaritinga-SP-Brasil watershed, using the free software Google Earth Pro.

MATERIAL AND METHODS

The study was carried out in the region of Latitude 21°22'12.94"S and longitude 48°26'29.97"W of the highest region of the Taquaritinga hydrographic basin, which belongs to the Tietê-Batalha Hydrographic Basin Council (CBH-TB). A sample area of approximately 3581ha was designated for the study (Figure 1), performed with the "line" tool, in the "circle" tab of the free software Google Earth Pro (2021). From this sample area of 3581ha, it was divided into 4 quadrants, using Google Earth Pro tools according to the findings of Rodrigues, Bovério and Ferrarezi (2020). Figure 1 shows the main study area and highlighted in color the elements of Quadrant 1, figure 1.

The elements of the rural landscape to be identified in the 4 quadrants through the use of the "polygon" tool, where there is information on the perimeter and area of each of the elements in each of the quadrants. The measurement of semi-perennial crops (CSP), represented by sugarcane, was performed 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 carrier elements and impermeable area, which corresponds to the asphalted road

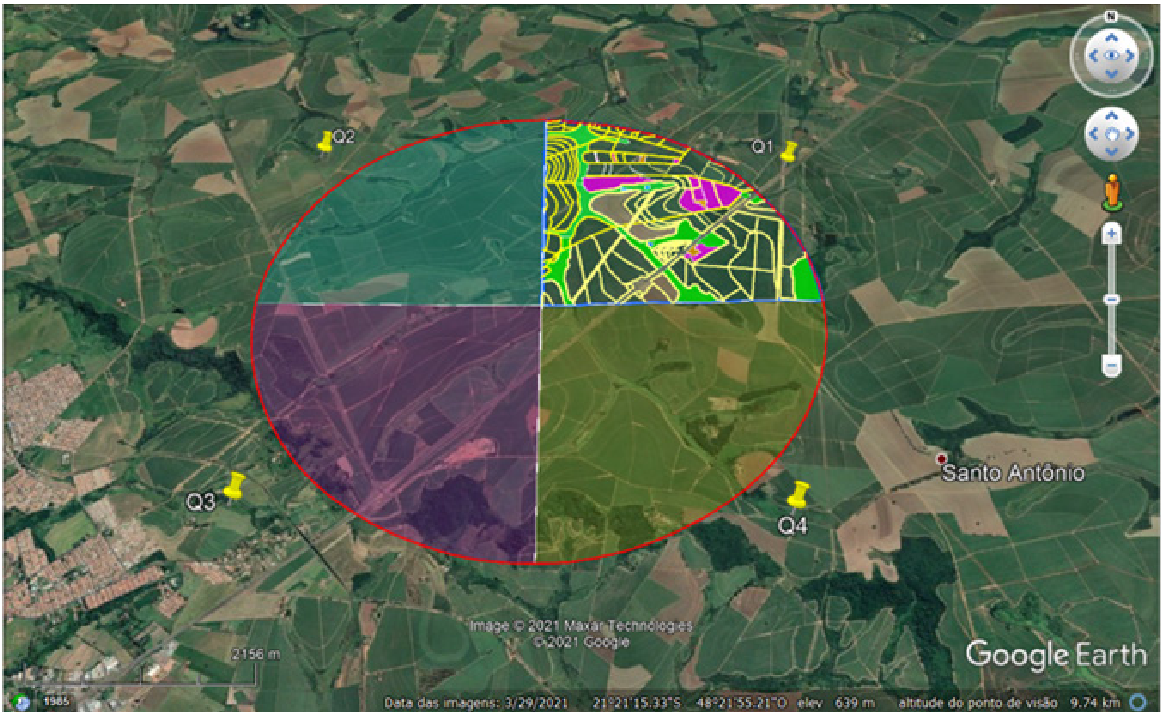


Figure 1. Sample area of the highest region of the Taquaritinga watershed, SP.

Source: Google Earth Pro (March 2021); Q1, Q2, Q3 and Q4: Quadrants of the sample area of 3581 ha.

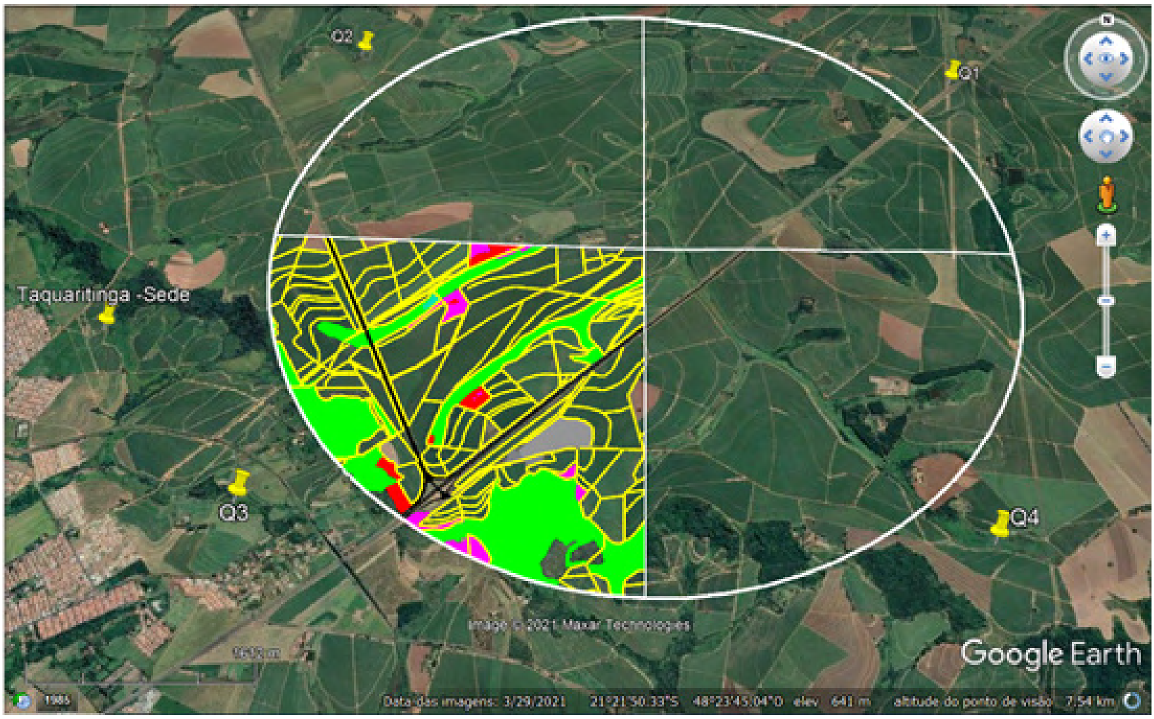


Figure 2. Sample area of the highest region of the Taquaritinga watershed, SP.

Source: Google Earth Pro (May 2021); Quadrant 3: highlighting the main elements of the landscape: APP areas (light green), areas of woody crops (pink) and rural construction areas (red), Carreadores (yellow), Institutional Area (grey), impermeable area (black) and Sugarcane growing areas (dark green).

domain area in the 4 quadrants (Figure 2). To calculate the area of skids (uncovered ground), the various types of skids in the quadrant were considered, which have variable widths. For that, 10 widths of the skids present in each quadrant were sampled at random, in order to have an average width of the skids and, using the total length of skids, multiplied by the average width of skids, it was possible to estimate the probable area devoid of ground. The paving areas followed the same logic. Once the lengths of the entire paved area in the quadrant were determined, the area of this quadrant was the result of multiplying the length by the width of the asphalt pavement.

Permanent Preservation areas (APP), Construction areas (AC), Woody Crop areas (CL), water mirror areas (ED) were determined the perimeter and area directly when using the "polygon" tool. The Semi-Perennial Crops (CSP), represented by the sugarcane crop, was determined by subtracting the total area of the quadrant, and all elements of the rural landscape. As construction areas, clear images of masonry houses or sheds and part of an outline, sometimes composed of pastures, sometimes composed of different fruit trees or native species, and finally degraded areas, were considered.

For the organization of the data, Excel software was used for the data measured in hectare when corresponding to the area, and the elaboration of the percentages of each element of the landscape in relation to the total area of the quadrant. For the statistical analysis of the data, the quadrants were considered as repetitions, and as treatments only the data that had repetition greater than or equal to 4 evaluations in each quadrant. In this case, only APP areas, carriers (paths) and sugarcane crop areas (Talhões) could be statistically analyzed. The other elements could only be verified. The completely randomized design with 4 repetitions was applied for the analysis of variance by the Fisher-Snedecor F test, and for the test of averages the Scott Knott test, both at 11 % of probability, using the free software Sisvar, version 5.6, of Ferreira (2008).

RESULTS AND DISCUSSION

The results of the analysis of variance of the landscape elements that stood out the most in the visualizations during the study showed that there was no significant effect of the size between the sugarcane stands (CSP), the length of the sugarcane trails and permanent preservation areas (APP) at the level of 11% probability (Table 1). The means test showed that there was a significant difference ($P<0.11$) only in terms of the size of the sugarcane stands. The results of the quantification of elements of the rural landscape that can be quantified or visually identified are shown in Graph 1. It appears that the four most expressive elements in the landscape correspond to the cultivation of sugar cane (75%), followed by conservation areas permanent (APP= 15.1%), woody crops (3.1%), carriers (CA= 3.96%), construction areas (AC= 1.12%), paved areas (impervious) (AP= 0.76%), institutional areas (AI= 0.42%), degraded areas (0.0012%) and water mirror (0.06%) making a total of 3581ha. Since the total area of this study corresponds to 3581ha, according to the new forest code the areas destined to the legal reserve (RL) must correspond to close to 20% of the quadrant area, that is, 716.2ha.

The existence of significant legal reserve areas (RL) in the four quadrants was not clearly identified, occurring in part in the southern region of quadrants 3 and 4, due to the sample area layout including part of the slope area of Serra de Jaboticabal. Observing the study area, it appears that the areas of sufficient environmental fragility correspond

Analysis of variance regarding the size between the sugarcane stands					
FV	GL	QM	Fc	Pr >Fc	
Treatment	3	105,601	2,776	0,103*	
repetitions	3	47,959	1,261	0,345	
Residue	9	38,04			
CV (%)	Test of averages of sugarcane plots				General Average
32,55	Q1**	Q2	Q3	Q4	18,95 ha
	14,06b	19,55b	16,30b	25,87a	
Analysis of variance of the length of sugarcane carriers					
FV	GL	QM	Fc	Pr >Fc	
Treatment	3	0,295	0,343	0,79[ns]	
repetitions	3	2,394	2,776	0,10	
Residue	9	2,587			
CV (%)	Test of averages of sugarcane carriers				General Average
40,71	Q1**	Q2	Q3	Q4	1,31 km
	1,18a	1,19a	1,38a	1,50a	
Analysis of variance referring to Permanent Preservation Areas					
FV	GL	QM	Fc	Pr >Fc	
Treatment	3	151,08	0,548	0,661[ns]	
repetitions	3	2234,60	8,110	0,006	
Residue	9	275,69			
CV (%)	Test of Averages of Permanent Preservation Areas				General Average
50,33	Q1**	Q2	Q3	Q4	32,98ha
	24,22a	33,25a	36,70a	37,75a	

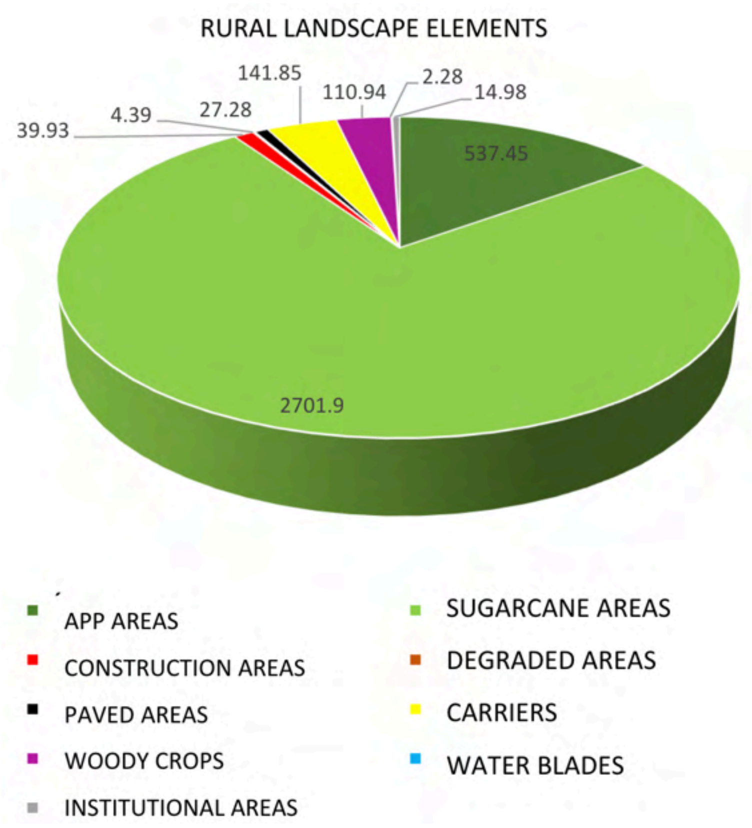
* Indicates that the test was significant at the 11% probability level; ns: indicates that the test was not significant;**Equal lowercase letters on the same line indicate that the test was not significant at the 11% probability level by the Scott Knott test; FV: source of variation; GL: Degrees of freedom; CV: Coefficient of variation.

Table 1. Summary of analysis of variance of the effects of stand sizes, length of skids and sizes of permanent preservation areas in the sample area of the highest region of the Taquaritinga watershed, SP.

to the areas surrounding the controlled landfill in Quadrant 3 (Figure 3), which has a significant potential for contamination of the water table (GOUVEIA ePRADO, 2010; GIACOMAZZO eALMEIDA, 2020) in the short term, and longer term from the Bauru aquifer, due to leachate percolation.

It is also noted that the waterproofing area is present in the 4 quadrants, represented by the asphalt of two highways, one that connects Taquaritinga to Jaboticabal, SP, and another that connects Taquaritinga to Monte Alto, SP. Taquaritinga to Jaboticabal is formed by a double lane and equipped with adequate conservation of slopes, internal channels for rainwater drainage, between the two lanes, and the construction of rainwater containment basins (Figure 3) on the banks of a rural road, which is a positive measure in conserving the water resource.

The study area is still well equipped with contour lines and the presence of straw on the ground due to the mechanized harvesting of sugarcane, especially in Quadrants 3 and 4, which is a highly recommended practice that can mitigate a possible degree of erodibility of a given region or even to avoid erosivity by rain that can place the watershed in a degree of environmental fragility (SANTIAGO et al., 2019). In this study, the presence of straw shown by satellite images can be inferred that the The presence of straw on the ground has a very positive aspect to mitigate eventual losses of soil and organic matter, contributing to the sustainability of the agricultural production system (SOUSA, MARTINS FILHO and MATIAS, 2012).



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

Source: Google Earth Pro (May 2021).

Figure 3. Highlight of the main landscape elements in quadrant 3, larger red outline, represents the controlled landfill in Taquaritinga, SP.

Source: Google Earth Pro (May 2021); In yellow outline the rainwater containment basins.

Figure 4. Highlighting a landscape element in quadrant 4.

Source: Google Earth Pro (May 2021); red outline represents a single degraded area in the sample area of 3581ha.

In the APP areas of the studied area, it is noted that the existence of artificial and natural water mirrors are rare. Such landscape elements have their natural function of ecosystem conservation, as it enriches the habitat that can be better explored by wild animals for drinking water, but their margins and interiors are contaminated by grasses. Furthermore, it is perfectly observable that there are native plants, but very sparse, which denotes a source of food and shelter for wild animals in precarious conditions. Such vulnerabilities are in agreement 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 that are triggering the situation of environmental vulnerability in the basin under study can be reversed in the medium and long term by seeking remediation alternatives (Cunha, Ritter and Borba, 2014). According to Costa (2018), through consistent public policies and the orderly management of watersheds, the ongoing vulnerability process can be mitigated, as long as it involves several agents (Castro, 2012), including rural producers, public agents of extension or not, within the hydrographic basin committee, the municipal government and the sugar and ethanol sector active in the hydrographic basin. Therefore, the adoption of geotechnologies becomes preponderant to respond with greater speed and quality to the increasingly growing and diverse demands of public policies (Guiaet al., 2016).

Conservationist soil and water management practices, cited by Tucci (2005), if implemented in a given basin allow positive changes to the landscape and positively influence the yield of agricultural activities. Different landscape changes can be confirmed by satellite images through photocomparison, a fully possible methodology for monitoring and even agro-environmental rehabilitation for the management of watersheds (Vichi Filho et al., 2016).

CONCLUSION

The main vulnerabilities detected in the region under study concern the areas of environmental protection, the legal reserve, in disagreement with the legislation. The areas of permanent preservation are contaminated with various forage grasses, are rare with native woody plants and surface water courses 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. Excessive cutting of sugarcane areas, divided by carriers, results in a considerable area of bare soil. The area in question presents as positive points the presence of straw on the ground, contour lines and containment basins, but the latter in a reduced number as conservation measures. The area under study indicates attention to the development of projects to restore native plants, associated with the construction of more containment basins, which can contribute in the long term to improve the infiltration of water resources in the basin.

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