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GEOMORPHOLOGICAL FACTORS IN THE CONTRIBUTION OF THE OCCURRENCE OF EROSIVE PROCESSES AS ROADS OF THE TO-445 ROAD, MUNICIPALITY OF MIRACEMA-TO

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Abstract

Erosive processes are phenomena in which unconsolidated materials from the earth's crust are broken down and transported by agents of nature such as water, wind and ice, they can be accelerated or caused by anthropic actions. The present work consists of the survey of geographic data that allows an analysis of stretches more prone to the treatment of erosive processes such as the margins of the TO-445 highway, between the cities of Miracema and Lajeado do Tocantins, in the state of Tocantins. Seeking to understand how variables of the physical environment, interactions and activities in the development of erosions close to the highway and how pathologies (defects), have an asphalt layer of the road, were performed or bibliographic survey and data analysis made available by SEFAZ, TOPODATA and INPE, the following data being processed using geographic information systems (GIS) using the QGIS software. As areas with the presence of erosive processes, they were identified by means of geoprocessing using satellite images via Google Earth Pro. Through the correlation between vertical and horizontal curvature maps, terrain shapes, slope, hypsometry, geology, geomorphology, soils and use and occupation, it was possible to use the behavior of factors that influence and cause processes of erosion such as the margins of the highway, as well as the points most prone to the appearance of pathologies in the lane of the highway under study.

Keywords: Erosions. Geoprocessing. Highways

FATORES GEOMORFOLÓGICOS NA CONTRIBUIÇÃO DE OCORRÊNCIA DE PROCESSOS EROSIVOS AS MARGENS DA RODOVIA TO-445, MUNICÍPIO DE MIRACEMA-TO

Resumo

Processos erosivos são fenômenos nos quais materiais inconsolidados da crosta terrestre são desagregados e transportados por agentes da natureza como água, vento e gelo, podendo ser acelerado ou mesmo provocados por ações antrópicas. O presente trabalho é composto pelo levantamento de dados geograficos que permite a análise de trechos mais propensos ao surgimento de processos erosivos as margens da rodovia TO-445, entre as cidades de Miracema e Lajeado do Tocantins, no estado do Tocantins. Buscando entender como as variáveis do meio físico interagem e atuam no desenvolvimento das erosões próximas a rodovia e as patologias (defeitos) presentes na capa asfáltica da via, foram realizados o levantamento bibliográfico e a análise de dados disponibilizados pela SEFAZ, TOPODATA e INPE, sendo os dados processando-os por meio do Sistemas de Informação Geográfica (SIG) através do software QGIS. As áreas com presença de processos erosivos, foram identificadas por meio de geoprocessamentos utilizando-se imagens de satélite via Google

Earth Pro. Através da correlação entre mapas de Curvatura vertical e horizontal, formas do terreno, declividade, hipsometria, geologia, geomorfologia, solos e uso e ocupação, foi possível compreender o comportamento dos fatores que influenciar e causar processos de erosão as margens da rodovia, bem como os pontos mais propensos ao surgimento de patologias na faixa de rolamento da rodovia em estudo.

Palavras-chave: Erosões. Geoprocessamento. Rodovias

FACTORES GEOMORFOLÓGICOS EN LA CONTRIBUCIÓN DE LA OCURRENCIA DE PROCESOS EROSIVOS COMO CAMINOS DEL CAMINO A-445, MUNICIPIO DE MIRACEMA-TO

Resumen

Los procesos erosivos son fenómenos en los que los materiales no consolidados de la corteza terrestre se desglosan y son transportados por agentes de la naturaleza como el agua, el viento y el hielo, que pueden acelerarse o incluso ser causados por acciones antrópicas. El presente trabajo consiste en una encuesta de datos que permite el análisis de tramos más propensos a estos procesos erosivos a lo largo de la carretera TO-445, entre las ciudades de Miracema y Lajeado do Tocantins, en el estado de Tocantins. Buscando comprender cómo las variables del entorno físico interactúan y actúan en el desarrollo de erosiones cerca de la carretera y las patologías (defectos) presentes en la capa de asfalto de la carretera, SEFAZ, TOPODATA e INPE pusieron a disposición una encuesta bibliográfica y un análisis de datos. Los datos fueran procesados a través de los Sistemas de Información Geográfica (SIG) a través del software QGIS. Las áreas cuyos cambios fueron causados por acciones climáticas, geológicas y mejoradas por acciones humanas, se identificaron mediante geoprocesamiento utilizando imágenes de satélite (Google Earth Pro). A través de la correlación entre los mapas de curvatura vertical y horizontal, las formas del terreno, la pendiente, la hipsometría, la geología, la geomorfología, los suelos y el uso y la ocupación, fue posible comprender el comportamiento de los factores que influyen y causan procesos de erosión a lo largo de la carretera, así como Los puntos más propensos a la aparición de patologías en el carril de la carretera en estudio.

Palabras-clave: Erosiones. Geoprocesamiento. Carreteras.

1. INTRODUCTION

The flow of water in soils can percolate and generate mass movement, where such adversity is a consequence of several factors related to the relief characteristics of the place, bringing as a result the possible deterioration of a paved region and its surroundings. The studied area in question is the TO-445 Highway, which connects the municipalities of Miracema do Norte to Lajeado, both in Tocantins. A stretch of highway widely used to reach the capital Palmas, which has a great social weight.

According to the National Transport Confederation (CNT, 2017), the most common flexible pavement in the country has an estimated useful life between 8 and 12 years. However, the reality is different, on average with seven months of construction problems (pathologies) are already observed on the highways (CNT, 2017). These adversities are due to a series of factors, from the materials used, as well as climatic and weather conditions, slope of the terrain, among other topographic and geomorphological conditions. It is observed that studies are needed to conserve pavements in Brazil, where the useful life of the highways is totally inconsistent with the estimated project.

Another factor that brings more relevance to the analyzed region, is its location in the hydrographic basin of the Tocantins River and having in its extension some micro basins that proceed to drain into the Tocantins River. All these factors added to a region characterized by a tropical season with a high volume of rainfall in a short period of time, further favor the linear and linear erosion processes.

The area explored in the research was studied from data analysis generated by programs called Geographic Information System (GIS). Satellite images were used through Google Earth Pro to identify points with evident erosive processes.

The Quantum GIS (Qgis) programs were used to identify the characteristics of topographic relief, based on the production of maps, such as: Hypsometry, Declivity, Terrain Forms, Geology, Geomorphology, Hydrographic Basins, Land Use and Occupation, which are the points most susceptible to soil mass loss according to the region's characteristics.

Correlating all these data, it was possible to obtain the results relevant to the susceptibility of pathologies on the road and erosive processes along the highway.

The objective of this research is to use Geographic Information Systems, to identify the influence that geomorphological characteristics have on the emergence of erosive processes on the margins of highways, as well as on the incidence of pathologies in the lane of the highway itself.

In this research, the term pathology was adopted by civil construction, to name defects that may arise in pavements. Such manifestations on flexible pavements can be classified into surface defects, surface degradations and deformations. The pathologies can originate from the functional imperfections, which is determined by its capacity for immediate functional performance that the floor provides to the user. They can also be of structural origin, in which the structural evaluation of pavements summarized in the analysis of the measures of recoverable vertical displacements of the flexible pavement surface, when subjected to a loading.

All maps obtained were made using the database of the State of Tocantins Finance Secretariat (SEFAZ-TO), the Brazilian Geomorphometric Database (TOPODATA) and the National Institute for Space Research (INPE), which is an important one object in the study of the geomorphological conditions of the region surrounding the highway under study.

Through the multivariate classification of the landscape that influences the runoff and erodibility of the entire region, it was possible to identify on the highway the points most likely to arise from pathologies due to the geormorphological characteristics of the region.

2. ENVIRONMENTAL DIAGNOSIS

According to Colen et al (2007) the area under study is located in a region characterized by only two well-defined seasons, a rainy period, varied from October to April, and a drought period, between May and September. SEPLAN (2002) describes the location of the study area as a humid climate, with moderate water deficiency in winter. Its average annual rainfall is set at 1800 mm with an average annual temperature of 28 ° C, and is found in the hydrographic basin of the Tocantins River.

SEPLAN (2002) classifies the soils of the study area with a greater presence of quartz sand. The relief of the region has a predominance of accumulation forms, reliefs resulting from the deposit of sediments, in fluvial regions and normally subject to flooding. The locality has a cerrado type vegetation with a use of soil and cover for grazing.

It is interesting to note that the rainy season is marked by frequent and intense rainfall in a short period of time, where this situation favors the appearance of erosions, since by the frequency of rain in a short period, the water cannot infiltrate the soil and ends up taking place of solid particles.

In the area in question, through field research, it was possible to identify laminar and linear erosions.

The study area is located in the hydrographic basin of the Tocantins River, where all the runoff from that region tends to meet the river and thus ends up modeling the terrain. It should also be noted that the region is marked by intense livestock farming, which ends up damaging the local vegetation at various points and unprotecting the soil from runoff.

3. METHODOLOGY

3.1. Selection of the Study Area

The study area represented in Figure 1, corresponds to a stretch of the TO-445 highway in the city of Miracema do Tocantins that connects the municipality to Lajeado, central region of the state, specifically in the space between the end of the urban area of Miracema and the bridge Northeastern immigrants Padre Cícero José de Sousa. The area in question is located on the left bank of the Tocantins River, integrating the referred basin, still having in its extension micro basins, which directly influence the conservation of the highway under study.

For previous identification of points susceptible to erosion, the Google Earth program was used. Subsequently, field research was carried out, aiming at visual verification of erosive processes on the margins of TO-445. From this visit, it was possible to identify basically ten points with a greater degree of erodibility.

The points mapped in the field were tracked with GARMIM navigation GPS, for the purpose of their simple location in the SIG database.

The first visit to the study area took place in a dry period, held in August 2018. Through this, it was possible to observe dry vegetation, mainly due to the period of greatest absence of precipitation, facilitating possible surface runoff (Figure 2).

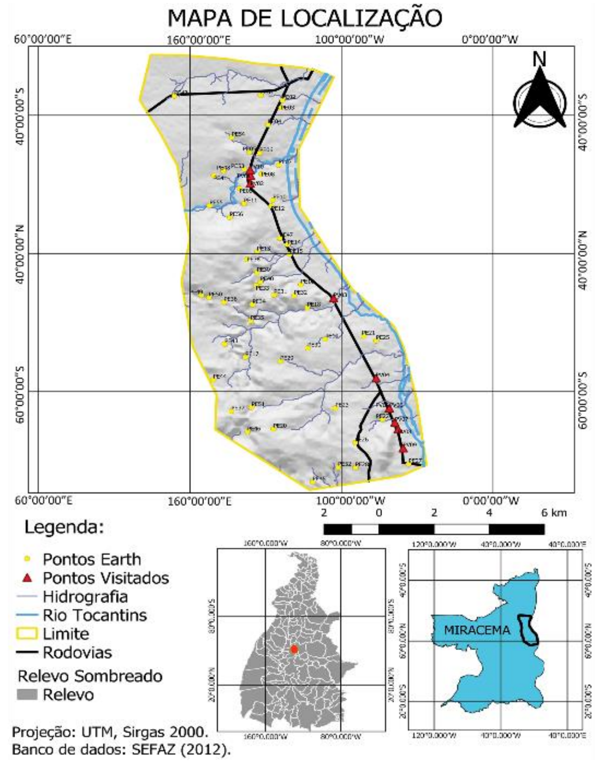

Figure 1- Location map of the study area. Source: author (2019).

Figure 2- Dry vegetation on the margins of the TO-445 road, with a possible preferred path at point P05. Source: author (2018).

During the period corresponding to the winter, a second field visit was carried out, in order to analyze the region and its behavior in the two seasons mentioned in the environmental diagnosis.

The rainy season is characterized by the formation of temporary basins, due to the preferential water paths, in some cases generating perennial rivers, which dry out during the summer.

3.2. Cartographic Documentation

In order to understand the influence of topographic relief and soil properties on the formation of damage to highways, the data provided by the survey were based

Web result with website links Secretariat of Finance and Planning (SEFAZ-TO), Brazilian Geomoformetric Database (TOPODATA) and National Institute for Space Research (INPE).

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The database made available by SEFAZ of the State of Tocantins was a reference for the development of maps of geology, soils and geomorphology. It is important to note that this database is on a scale of 1: 1.000.000, with the last update in 2012.

Understanding the diagnosis of the relief provided by the geology and geomorphology maps, correlating with the soil map, it was possible to establish a connection with the pathologies found on the highway.

TO-445 was chosen as a study area due to its geographical location. As will be seen later on in the Hypsometry map, the highway is located between the Tocantins River with low altitude and several hills with higher altitudes.

Bearing in mind that water resulting from precipitation, during the runoff process seeks easier ways to travel, there is a natural tendency for water to drain from points of higher altitude towards points of lower altitude. Since the TO-445 highway is located between these points, it ends up being intercepted by the entire runoff process, causing structural pathologies to appear on the road.

Removing the vegetation cover accelerates the dragging of soil particles and in turn accelerates the flow rate, being fundamental in determining the use and occupation of any basin that may contribute to the emergence of pathologies on the study area. For this, the use and occupation map was generated.

Due to the low scale of the SEFAZ database, the land use and occupation map was generated in a new supervised classification in the QGis software, scaling through the INPE database, in which the LANDSAT-8 OLI sensor images were used (Operational Land Imager) and TIRS (Thermal Infrared Sensor) in the scale 1: 10000 and with 30 meters of precision.

Another key factor in determining the incidence of pathology on highways is the topographic relief, the slope being responsible for accelerating the runoff and the shape of the terrain responsible for defining points of concentration or dispersion of water flow.

To generate the slope maps, vertical and horizontal curvature, terrain shapes and hypsometry were resized via QGIS, using the TOPODATA database. This information base has SRTM images with a resolution of 90 meters and 3 arcseconds, which after processing reaches 30 meters of precision and 1 arcsecond.

The classification of vertical and horizontal curvature maps was based on that proposed by Valeriano (2008), using Figures 3 (a) and 3 (b) as a basis. Through such characterization, it is possible to better analyze and diagnose the relief present in the studied area, identifying regions more prone to the action of surface runoff and consequently loading of solid particles. The definition of such factors in the vicinity of the highway becomes essential for the continuation of the research.

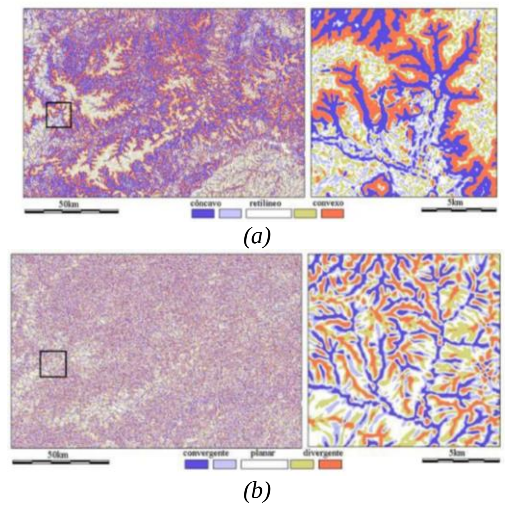

Figure 3- (a) Vertical curvature in five classes. (b) - Horizontal curvature in three classes. Source: Valeriano (2008).

Based on this, it is possible to arrive at the map of terrain shapes, which is understood as the junction of the two variables previously presented (vertical and horizontal curvature), generating classification according to Figure 4.

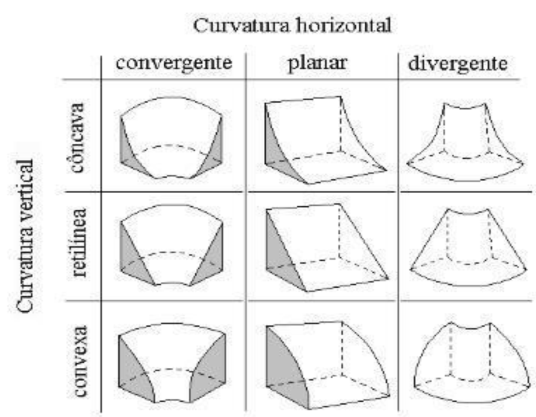

Figure 4- Terrain shapes: Combination of curvatures to characterize terrain shapes. Source: Valeriano (2008).

4. RESULTS AND DISCUSSION

In view of the above, it will be discussed about maps and relating them to the problem of erosion and runoff as a factor of pavement degradation, it will be possible to understand how the various variables are related, and in this way how they can be useful for a plan implementation of a highway or resolution of pathologies during its extension.

In March 2019, during a field visit, a significant amount of erosion was identified in the area, probably due to the rainy season. During this period there was also an increase in vegetation, allowing greater natural protection to the soil, although not enough to prevent degradation processes as a whole.

The erosions shown in Figures 5 demonstrate the concern in the study of the area in question, since they can lead to the destabilization of the highway, promoting its partial or total destruction in the next years, if there is no type of maintenance.

Figure 5 - Laminar erosion on a slope at point P10 along the TO-445 road. Source: author (2019).

4.1. Geology

Lopes and Saldanha (2016), show that the contribution of Geology to the analysis and definition of the morphodynamic category is the degree of cohesion of the rocks that compose it and data related to the history of the geological evolution of the region where the unit is present. The nature of the matrix rock, its mineralogical and chemical composition, and the original state of fracturing, have a major influence on the characteristics of the soil that originates therefrom. (AHMED, 2009).

The geology presented in the research area according to the geology map (Figure 6) is predominantly from Sedimentary Basins and Unconsolidated Sedimentary Deposits, with a greater presence of erosive processes in the Sedimentary Basins, places with great depressions in the relief favoring these erosions.

This geological arrangement of the site presents data from an area intensely affected by weathering and its mass movements, mainly because it is a place with high and low points facilitating these displacements, besides presenting information about how the region was formed since its tectonic processes during geological time.

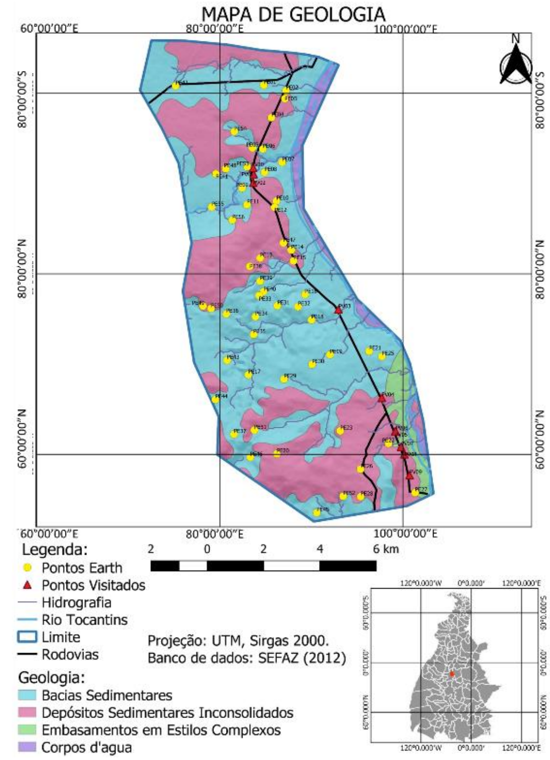

Figure 6- Geology Map. Source: author (2019).

In view of this, when analyzing the characteristics of a given region, everything starts from the principle of geology, which added to the other variables demonstrated shortly thereafter, will present more information about the location of the highway under study, correlating them as a determining factor in the formation erosive processes, runoff and consequently pathologies in the pavement.

4.2. Geomorphology

Oliveira and Chaves (2010) affirm that geomorphology has great importance in the knowledge of environmental phenomena, being able to show an integrated understanding of a landscape, being directly related to the characterization of the environment, seeking to diagnose the landforms.

From the Tocantins geographic database, geomorphology domains made available by Sefaz-TO the area under analysis was entirely classified as a geomorphological compartment for the Middle Tocantins Depression, and from the geomorphology database units the area was classified as morphostructural domains Basins Sedimentary and Unconsolidated Coverage (Figure 7). Villela and Nogueira (2011) describes this identity as a strip of the Tocantins River valley, of areas with low or intermediate declivity, with a dissection configuration with convex and tabular tops, where it is mainly affected by erosions of concentrated water flow, generating erosive processes such as furrows and ravines.

The geomorphological identity of the region indicates the vulnerable area in which the highway is located, due to its conformation of relief, it is characterized by a location conducive to erosions of the linear type, where these are frequent around the pavement, as we can see its incidence presented on the geomorphology map (Figure 7), being able to acutely damage the highway.

It is worth noting that geomorphology preliminarily describes the local topography, indicating regions where concentrated water flow occurs, that is, linear erosions. In addition to this, it is possible to have an idea of the slope, in which, it is a predominant factor in the understanding of the relief forms of a region subject to mass and fluid movements.

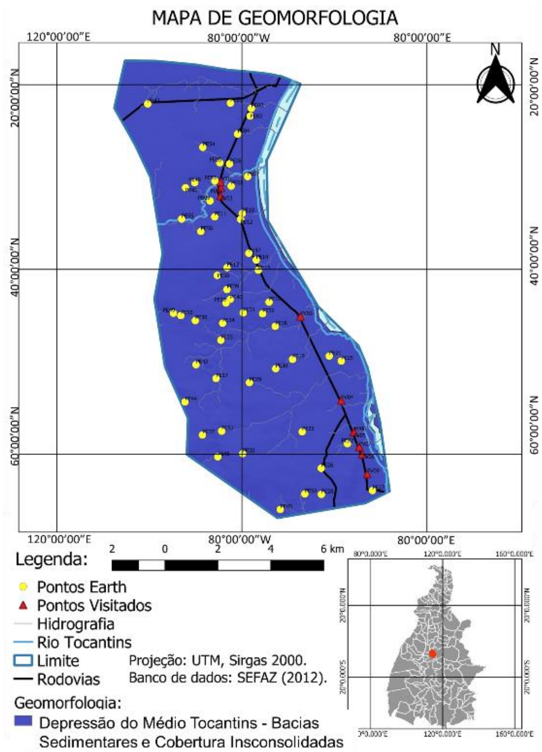

Figure 7- Map of Geomorphology. Source: author (2019).

4.3. Soils

Ahmed (2009) explains that the way in which soil particles are arranged has relevance in the amount of mass that is dragged in an erosion, in addition to exposing that the amount of organic matter in the soil also has a great influence on the susceptibility to erosion of a ground.

In this way, Brady and Weil (2013), indicate that for a better use of the researches carried out in a certain area, it is necessary to know the soil classification of this place, in such a way that it is possible to predict the behavior of these soils.

The present soil map (Figure 8) shows a domain in the Neossolo type soil site. According to Spera et al (1999) they are soils whose structure is formed mostly by sand. Thus, they are classified as excessively erodible, have a high drainage content, and little water retention.

On the other hand, in a considerable occurrence, the presence of Plintossol type soils, which according to the Brazilian Soil Classification System - SiBCS (2005), is composed of minerals formed under conditions of restriction to water percolation, they are subject to the short-term effect of excess moisture.

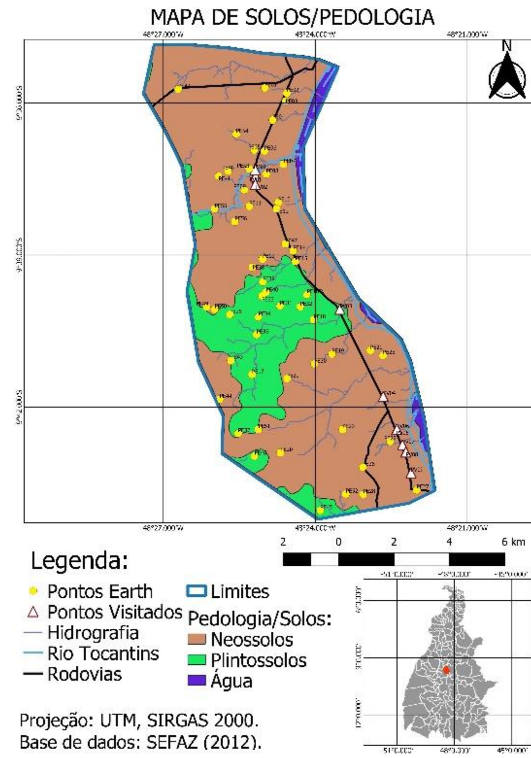

Figure 8- Soil Map. Source: author (2019).

Examining the soil variable, one can perceive the erosive vulnerability of the studied extension, a fact also registered in the field research. In addition to the damage caused by erosive processes that can evolve and reach the highways, there are pathologies arising from the percolation of water through the voids in the soil.

4.4. Hypsometry

The hypsometric map (Figure 9) presents the topographic profile of the study area, based on the altimetric variation existing at the location. In general, variations in altitude between 168 and 370m were observed, with some points of higher elevations between 371 and 421m. It is important to note that this elevation decreases as it approaches the highway under study, reaching its minimum point on the banks of the Tocantins River.

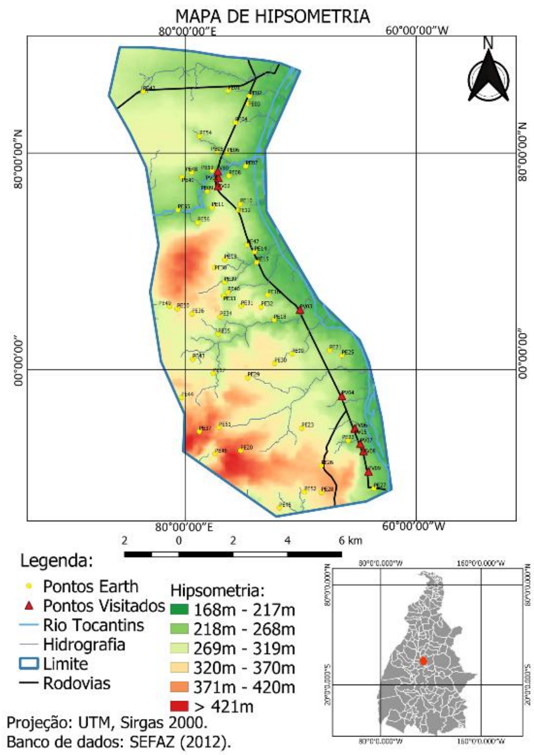

Figure 9- Hypsometry map. Source: author (2019).

Thus, the hypsometric representation of the hydrographic basin under study makes it possible to analyze the unevenness of the terrain. It is observed that the areas with greater erosion observance are located in regions with greater difference in levels.

Parallel to this, knowing that the highway is at a point of altitude change and noting that the runoff of the waters is prone to reaching the pavement before reaching its final destination, the highway becomes subject to erosion.

In Figure 9, it is possible to observe an expressive presence of erosive processes along the highway. The evolution of such processes due to runoff, can cause the appearance of structural pathologies (damages) on the pavement, if the proper interventions are not carried out, such as a good drainage system, containment structures and reinforcement with vegetation cover.

4.5. Declivity

The graphical representation of the slope of the region presents in percentage the slope of the terrain in relation to the horizontal plane, a very useful tool in the study of the surface runoff of the region, because the higher the slope, the greater the speed of water drainage and consequently there is a drag more aggressive of soil particles.

Iensen (2006) states that the speed of runoff is directly related to the slope, thus, the degree of slope is one of the most significant reasons in the erosion process, as the volume and speed of the runoff that percolate over the soil directly depends on it. dragging its particles.

In the graphical study carried out from the slope map (Figure 10), it is possible to identify areas in its predominance flat, with emphasis also on some points of strong undulation, with points of very high slopes (mountainous and steep) that help in the understanding of the runoff from the region.

Correlating the erosions found both remotely and in field surveys with the map, there is a greater disposition of erosions in regions of sudden change in slope, as seen in hypsometric maps, this transition zone is always well degraded, as the fluids are dragged aggressively from the highest points and with the highest slope and lose their potential strength when they reach the lowest levels, and in the process they damage the soil causing erosion.

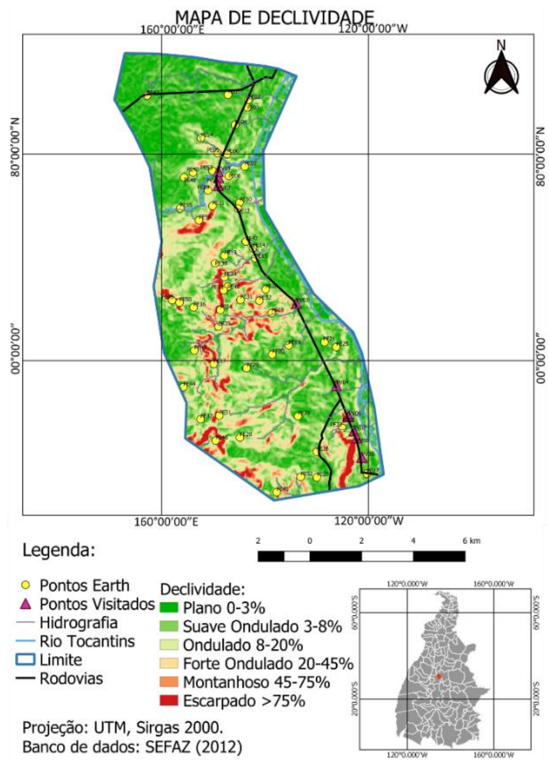

Figure 10- Declivity map. Source: author (2019).

As far as the highway is concerned, as already mentioned, this is within the trajectory of the waters that flow towards the river, which makes it a vulnerable condition. Knowing that this slope variable is one of the direct controlling agents of the volume and velocity of runoff over a given region, it influences not only the generation of erosions such as hypsometry, but also the appearance of other water-related pathologies in a road, such as for example wear and tear of the floor covering and excess water in the layers that compose it.

4.6. Formas do Terreno

The terrain shapes are basically divided into two variables: vertical and horizontal curvature, together defining the object of study for this topic.

According to Valeriano (2008) the vertical curvature is the shape of a slope when viewed in profile, and is also defined as the variation in the slope over a location or can only refer to the convex / concave shape of the terrain when analyzed in profile , and are defined in three types: concave, convex and rectilinear.

According to the analysis of the delimited area (Figure 11), there was a predominance of very concave regions, with convex points in the background.

On the other hand, the horizontal curvature (Figure 12) also studies the landscape, but in a horizontal profile, allowing the classification in: convergent, planar and divergent.

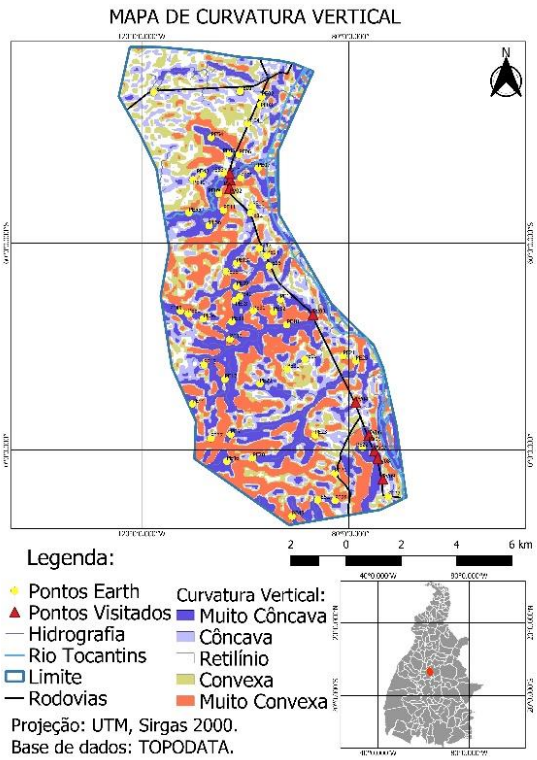

Figure 11- Vertical Curvature Map. Source: author (2019).

According to Valeriano and Carvalho (2003) the horizontal curvature refers to the divergent and convergent character of the courses of substances on the terrain when analyzed in a horizontal perspective. In which variable is associated with locomotion and concentrations of water in the extension of the soil through gravity.

In the study of the case in question, the area can be understood as very convergent in the foreground, although it is possible to highlight a minor convergence in considerable points.

In correlation of both variables mentioned above, the shapes of the terrain are obtained as a direct result (Figure 13), ensuring greater precision through the graphic analysis of the items previously studied separately. Based on this assumption, it was possible to identify and classify the objectified area in Convergent-Concave mainly, still standing out Convergent-Convex regions.

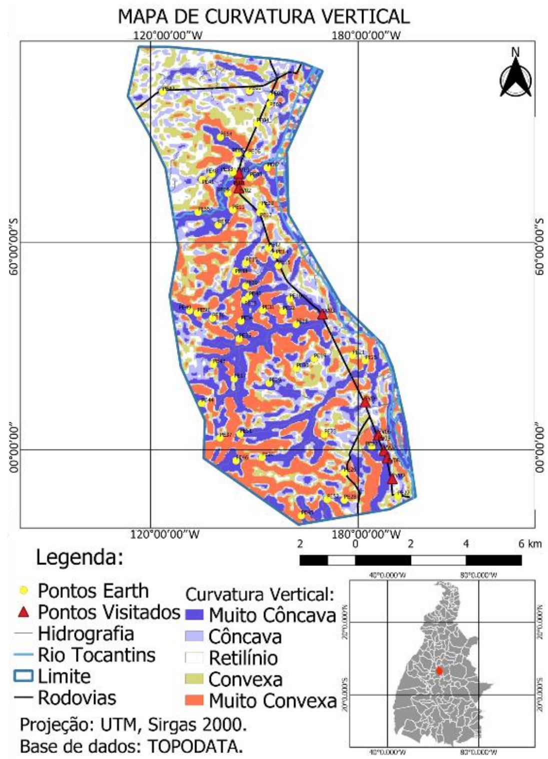

Figure 12- Horizontal Curvature Map. Source: author (2019).

It is necessary to point out that these two predominant forms of terrain have a configuration that facilitates the appearance of linear erosions, with a concentrated flow of waters, where their geometry collects the dispersed waters and accumulates them, generating a greater probability of more critical erosive processes. Valeriano (2008), for example, indicates that the most severe case of association of curvatures of the terrain in terms of maximum concentration and flow accumulation is exactly the convergent-concave configuration present in the area under study.

The tool called terrain shapes, adds hypsometry and slope and shows that the substances, displaced from the highest points that tend to flow into the Tocantins River, hit the highway aggressively due to the molding of the terrain that concentrates the flows and inevitably increases its drag force when it concentrates them.

It is a fact that this formatting of the local land, besides being conducive to the appearance of ravines and gullies close to the highway, also contributes to the emergence of pathologies related to the presence of water on the highway, especially with regard to the breakdown of the pavement, where water it will flow quickly and concentrated on reaching the pavement, as well as reaching pre-existing pathologies on the pavement arising from other circumstances and ending up further deteriorating the structure.

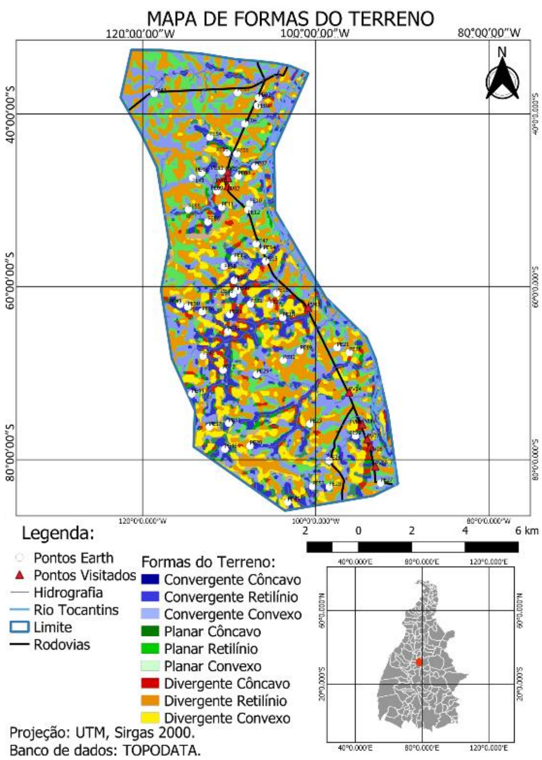

Figure 13- Map of Forms of the terrain. Source: author (2019).

It is important to emphasize again the importance of the vegetation cover existing in the region, which, although not in the proper proportion to protect 100% of the highways from the aforementioned adversities, contributes profoundly, preventing the highway from being in poor traffic conditions so soon.

4.7. Watersheds

The representation of the hydrographic basins (Figure 14) shows the Tocantins River on the right, one of the most important variables in the study of erosion processes in the region of the TO-445 highway, where all the water drained from the area in focus in the research goes, thus occurring mass movement during the percolation of these fluids.

However, it is also possible to see prominently some sub-basins of the Tocantins River, regions where a large number of erosive processes are also concentrated, so it is necessary to give due attention to the influences of these secondary basins in the formation of erosive processes, and relate them to the other variables of this project, since these basins can escape the rule, and concentrate the largest number of erosions in their surroundings.

These sub-basins represent directions of water flows, but in most cases they are not really characterized in a hydrography, as these regions in times of high rain incidence become only preferential flow paths with a high concentration of water, or perennial river , as verified in the field visits, but ends up being defined by the map as a hydrography.

It is necessary to reiterate that the route traveled by the waters of the secondary basins crosses the TO-445 Highway to reach the Tocantins River, leaving the region in times of rain extremely susceptible to erosion and the destabilization of the pavement, since the system of galleries and drainage from the inefficient highway in view of the large volume of water.

Another problem regarding the study of these hydrographic sub-basins is related to water concentrations very close to the pavement. These can enter laterally at the edges of the pavement, causing the appearance of several pathologies.

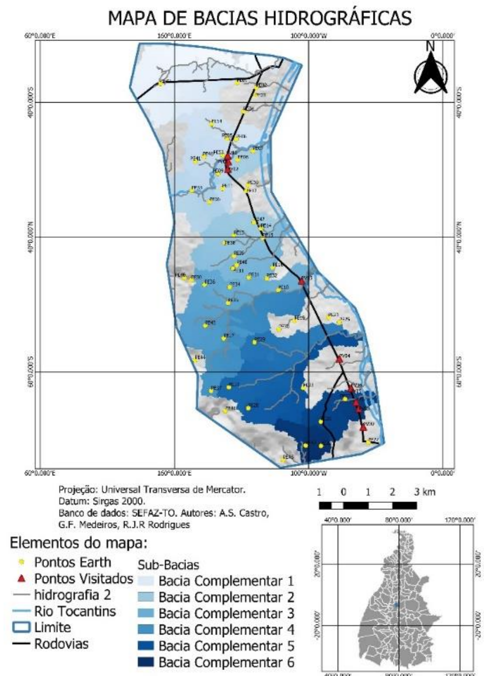

Figure 14- Map of Watersheds. Source author (2019).

4.8. Use and Occupation

Almeida (2015) approaches that the way in which the soil is used influences a lot in the erosive processes, construction of roads, deforestation, creation and expansion of cities, cultivation of lands and the livestock, where the latter occurs so that a great amount of animals tramples the soil and ends up changing its configuration, are examples of the use and occupation of the soil contributing to the acceleration of erosion processes.

The use and occupation shown in Figure 15, in the section corresponding to the municipality of Miracema, we can see the predominance of pasture area and secondarily areas intended for agriculture. During the field survey, the predominance of agriculture and livestock in the region can be confirmed.

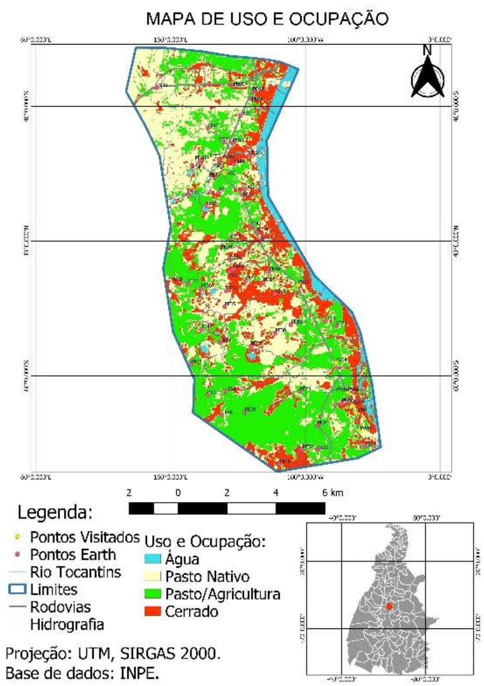

Figure 15- Use and occupation map. Source: author (2019).

As far as highways are concerned, these changes in man in the local landscape end up driving the speed of erosion processes, and affecting it precipitously. However, it is worth noting that the implementation of the highway is one of the biggest changes in the panorama of a region. Activities such as moving masses of soil (cut and fill) and deforestation significantly alter the relief and the runoff rates of precipitated waters.

The process of building the roads contributes to the formation of embankments, which have a slope, in general, prone to erodibility, so that this process must be done with due responsibility, seeking to address possible future problems and using geoprocessing as a guide for an integrated study.

Therefore, through the land use and occupation map, it is possible to obtain a broad view of man's interference with the environment. Where from this representation, one can have the conception of the causes and dimension of the development of erosive processes related to anthropic actions and not just the natural configuration of a given location.

4. FINAL CONSIDERATIONS

In view of the above, the present work used the tools of Geoprocessing as allies in the study of erosive processes and the runoff of water, in addition to the interrelationship of several landscape variables of a given region as an agent of road degradation.

Using the Qgis software, maps of hypsometry, slope, terrain shapes, geomorphology, geology, soils, use and occupation and hydrographic basins of the region were generated. These maps were the variables of analysis of the region and successfully presented information about the region, which can help prevent erosion and pathologies on the highways.

The topographic variables presented data regarding runoff, and the high probability of the existence of linear erosions in the study region, facts verified in the two field visits and recorded with photos in the study area. Combined with runoff, it is also possible to infer the degradation of the floor covering due to excess moisture.

It is necessary to add the feasibility of working with geoprocessing in the area of civil engineering, in which it became possible to extract a large number of information from a paved region without the need for several field visits, being of great value in any preliminary project. roads and highways. Parallel to this, it is necessary to make it clear that the field visit is still of great value, and should not be suppressed, as from inspection in the area it was possible to understand how the variables are integrated in practice.

Finally, the research was able to present the feasibility of studying the pathologies of a road associated with the susceptibility to erosion and the surface runoff of the region in which the road is inserted, understanding its entire geomorphological configuration and also making it possible to set a precedent for greater use of geoprocessing as a great ally in civil engineering, as it is an inexpensive tool, extremely fast and with satisfactory results.

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