

# **THE GULLY FORMATION PROCESSES OF THE BASINS AND THEIR IMPLICATIONS ON THE SLOPES STABILITY, A RELIEF EVOLUTION MODEL ON THE BRAZILIAN SAVANNA DOMAIN**

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This article brings on the results of specific studies over erosion carried out for twenty years by a crew of researchers of Universidade Federal de Uberlândia. The researches at all took place in Uberlândia, Monte Carmelo, Iraí de Minas counties and others, prior focusing the basins of Douradinho at Uberlândia, Pantaninho and Divisa at Iraí de Minas and Boa Vista at Prata.

This Triângulo Mineiro specific area has been through several geographical changes over the twentieth century implying alteration on its landscape structure. According to this, the need of knowing the processes dynamic as well as the diagnoses methods and also how to elaborate bating corrections and means to recover degraded areas has become extremely necessary. The main goal was the identification of either the mechanisms or the conditions stablishers responsible for erosion processes.

“The tropical environment is characterized by a damaged landscape composed by potentially affected areas and others recently occupied which present initial effects. Both the areas need planning research. Whenever those environments get altered by human action, their fragilities show up” (Baccaro, 1994:19).

The gully formation processes at the basins have been developed and/or dynamized by uncontrolled human action and its improperly usage of soil and occupation of the area not considering its dynamic balance limit. This limit represents how far the environment naturally stands for antropic alterations not destabilizing the slopes and generating irreversible catastrophic consequences.

It is required a large knowledge of the superficial structure and its dynamic in order to identify the dynamic balance limit and also to elaborate the environmental diagnoses which details either the potentialities and fragilities considering the area, also giving information on how to better occupate it.

The Triângulo Mineiro area presents several accelerated erosion problems in its soils. By deforesting the natural vegetation, the savanna domain itself and the cultural border expansion over the natural domains has caused erosive processes such as the formation of gullies and ravines and it also speeds up the erosion in the basins. In 1990 Baccaro developed a study on Douradinho Basin analysing the geomorphological processes considering the pluvial flow and how it contributes on the gullies evolution. The author realized that the gullies formation on the referred basins had become consequence of factors such as the ditches built by farmers to separate properties, the 'carro-de-boi' (native transportation device) and the cattle tracks.

In her later studies (Baccaro, 1991; Baccaro, 1994; Baccaro, 1999 and Baccaro et al 2002), the author identified the connection between the gully formation process and the specific geomorphological area unit characterized by its shape, by its dehydrate level and the superficial formations.

Considering these parameters Baccaro (1991) has elaborated the Triângulo Mineiro topographical partitioning in the following units: Intensively Dehydrated Surface Areas, Moderately Dehydrate Areas, Residual Surface Areas and finally Wide and Flat Elevated Summit Areas.

The next step led Baccaro to a veticalized way of studying it, investigating the Landscape Fisiology. In this period, the current landscape dynamic has started being analyzed by means of identification, mapping, characterizing and monitoring the accelerated gully formation process. It has been used a wide range of methodology emphasizing the bibliographical reviewing, the mapping and the experimental stations including the process monitoring and the laboratorial analyzes.

The researches take the watershed as the specific unit to analyze the mechanisms and the condition stablishers for the erosive processes. Inside the watershed, the refference for the analyze categories is the slope itself, since that's where the antagonism between endogeneous and exogenous strenghts take place in addition to human actions which results at all the surface shapes.

The conditions stablishers for the erosive processes are the rain, the vegetal cover, the surface, the soils and the rocky substratum. According to Carrijo, "the rain, the vegetal cover and the topography are the extrinsic factors related to the erosion process. On the other hand, the soil may be considered as an internal factor since it affects and its affected by the erosion" (1999:28).

Hence, each of the conditions establishers have been considered in the erosion dynamic analyze. The first one is the rain erosive strength and its investigative parameters are: rain intensity, the rain amount, the momentum and finally the kinetic energy. Isolated, the rain amount is not enough to specify the soil erosion. Otherwise, the rain intensity is extremely important to predict the soil disruption and it is directly related to the rain kinetic energy. The rain momentum is calculated by multiplying its mass versus the rain drop speed and it is associated to the capacity of dragging away the loosen soil particles (Guerra, 1995).

The rain water is the main factor in erosive processes. It starts when the rain drops hit de ground. For uncovered soils, the collision will implicate the splash erosion proportioning the detriments carrying. Subsequently, these drops generate the so called laminar erosion, literally washing the surface and finally it's possible the formation of highly concentrated flow responsible for opening ravines and channels which may evolve to gullies, the last step in the erosion process. In the gully formation process, besides the superficial erosion the under superficial "piping" type also takes place, thus generating the dismantling and sloping of the walls at the gullies.

The vegetal cover density is another important condition establisher for the erosion analyze. The density and the vegetation type offer different degrees of protection for the soil, determining how the erosion process will evolve and the formation of it (Carrijo, 1999).

The surface shape also implies on the erosive process. Besides the topographic gradient and the declivity, the slopes shape also contributes to accelerate or to reduce the process (Carrijo, 1999).

The soil characteristics may be analyzed in details, since those determine the susceptibility to erosion. The texture, the permeability and depth are important factors to specify this susceptibility degree.

The geological formation implies on the subterranean waters behavior and it will influence the soil shape after the process.

The dynamic and evolution of the gully formations at Triângulo Mineiro present different frequency and magnitude as well as the starting points. Some of those get started due to bad use of soil and because of deforestation. Others are initiated due to pasture and burnings associated to the rain intensity and the soil characteristics.

The research results have indicated some similarities considering the processes dynamic for the analyzed areas. In Prata county, specifically at Boa Vista and Peixotos Basins, the gullies had its dynamics determined by either the concentrated superficial flow

and the by the soil sandy texture. The increase of the concentrated superficial flow occurred as a consequence of deforestation of the natural initial vegetation on top and in the valleys. At Uberlândia, 217 gullies have been mapped. Most of the accelerated erosion processes for this county are located at Tijuco Basin and its following affluent: Estiva, Douradinho, Macacos, Babilônia, Panga and Água Limpa. These gullies formations are conditioned to certain natural elements in landscape such as the superficial formations highly concentrated in thin sand, the moderately dehydrated surface shapes at convexo-concave hills, declivity over 5°, the soil usage and the area occupation historic.

Most of those gullies are connected to the basin by retraction and upward erosion. Baccaro (1999) emphasizes a direct relation between the erosions and the interflow dismantling, the abasement of the ground water levels as well as the illegal subterranean water deviation. Analyzing the gully formation process at Córrego da Gordura, Baccaro et al, 2002 identified as being “accelerated slope instability erosion directly related to the structure (geological, geomorphologic and pedological), to the slopes, to weather conditions and finally to human actions. The dynamic and the erosion process referred above is similar to the process which takes place upstream the incline disruptions stood by the silto-sandy structure of Marília Formation, over 800m height. The ground water is located next to the surface and the exfiltration process generates several slope formation processes arising from the ground water hidrous dynamic. These processes beyond contributing for the festooning of the gullies, also cause an increase in the water fluvial volume even in the basins, implying on a more intense vertical incision which creates several small depth channels and increases the carrying erosion strength due to its potential and kinetic energy. In the contact area between silto-sandy and conglomeratic faces, the fluvial water carved a knickpoint stood by the rocky threshold of Marília Formation. Bringing it to a limit point the following situations may occur. Upstream, the gully will open up and downstream the valley will get thinner. The under superficial water acts as tunneling erosion causing the walls crumbling and creates a specific area where the pipeflows are extremely important in the river banks dismount dynamic. Also important is the fact that the rain water can accumulate in tracks left by the cattle and inside the piping which drags out the excessive water off the roads into the gullies, thus implying on the “waterfall effect” and contributing for erosion at the gullies basement and carrying out the sediments” (2002:20 and 21). This specific area of Tijuco’s Basin had been indicated by Baccaro (1994) as priory, considering the fighting erosion control plans in Uberlândia County. Boa Vista Basin is being analyzed and studied considering the hydrologic and geomorphological points of view in order to accomplish definite recovery proposals.

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