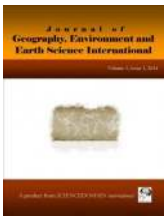

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The Impacts of Gullies in Zé Açu Micro-watershed, Brazilian Amazon

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Authors' contributions

This work was carried out in collaboration between all authors. Author JBP designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors CHO and CHS have mentored the study. All authors read and approved the final manuscript.

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ABSTRACT

The gullies represent the most complex and destructive way of soil degradation relative to linear erosion. In this context, the goal of this study is to address the impacts of gullies in the longitudinal profile of the *Zé Açu* Micro-watershed, at the Settlement Project (SP) Amazonian Village, Parintins municipality, Amazon State, Brazil and, as consequence of that, the impacts to the family farmers living there. Methodology: a) *Cognitive Map*; b) *Geoprocessing;* c) Field work from 2010 to 2012. Discussion of the results: Twelve gullies were mapped at the edge of the first order channels' headwater in an area of extensive livestock. The upper stream is the more affected by the colmatation of tributary channels and the siltation of the mainstream. As consequence, in the river's ebb tide (August to December) there is the scarcity of water (direct impact on domestic use, irrigation, transport, quantity of fishes; Indirect impact described as no potability because of the high charge of suspend sediments). These impacts affect 07 traditional farming communities (416

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families). This problem leads to the vulnerability of local farmers and impacts can be seemed on their economy, social life and culture. Nevertheless, *Zé Açu* Micro-watershed is looking for its geomorphological reorganization, compatible with the new conditions that are imposed to it. The on-going changes, however, doesn't permit recovering the same ecosystem, due the loss of soil, fauna and flora.

Keywords: Water scarcity; gully; fluvial stream; Amazon.

1. INTRODUCTION

The environmental equilibrium and disequilibrium (climatic factors and elements besides biotic and abiotic environments) are intrinsically related with the land use and occupation. Therefore, vulnerability and risk of the environmental changes and hazards depends on the geneses and composition of certain natural system and the relation with the land use and its occupation.

Thus, it is impossible to separate the set of physical conditions that interacts with on living organisms. This framework is an evident global concern about environmental issues. The vegetation, for instance, is important for the climatic equilibrium, and this last one is connected to the hydrologic cycle which is essential for the living beings and their environment, demonstrating the cyclic interdependence.

Regarding the Amazon studies, Aguiar [1,2] indicated the relationship between vegetation cover and weather: the absence of vegetation may cause reduction in the permanence time of water in the drainage basin, by favoring the accelerated flow and, thus resulting also in a decrease of water vapor in the atmosphere, by the reduction of humidity in the whole system. This argumentation corroborates the various studies [3-7], wherein it is said that precipitation arises from the combination of locally evaporated water (evapotranspiration) with humidity contributions originated at Atlantic Ocean.

Several human activities can destroy vegetation like: deforestation and burnings can produce impacts on water, as so as the inappropriate prepare of the soil and consequent soil compaction [8]. According to Mello and other [9], the effects of these impacts may change the superficial flow in the basin, including the shift of drainage from perennial to intermittent one.

Molion [7], explained that when the soil suffers vegetation suppression by shallow cuts, this allows variations in diurnal moisture fluctuation on the soil surface because of the increase on air temperature and humidity, generating a decrease in the rainfall. When the vegetation is removed, there is an environmental impact. The soil loss is directly occasioned by this, and the loss of material isalso accelerated by hydric/pluvial erosion. In Brazil, the soil loss is around 2 to 2, 5 billions/ton/year [10]. Bertoni and Lombardi Neto when they studied a small area without green cover, the [11] y found data regarding the soil loss by pluvial erosion from 1.600 to 9.000 $MJ.mm.ha^{1}.h^{1}.year^{1}$.Fearnside concluded that aggressive anthropic impacts aggressive cause the loss of environmental services: biodiversity maintenance, water and carbon cycling which can regulate the greenhouse effect [12].

Focusing in this issue, this work aims to address the impacts caused by gullies in watershed longitudinal profile at the *Zé Açu* Micro-watershed, and, as a consequence of this, there is scarcity of potable water to the local family farmers.

2. STUDY AREA, MATERIALS AND METHODS

2.1 Area of Study

The study was conducted in the *Zé Açu* Micro-watershed. This drainage basin has an area of 126,923 km^2, in which the main stream has an extension of 19,512 km, from southeast (upstream - 56°33'15,368"W - 2°44'44,21"S) to west (downstream-56°39'40,336"W - 2°38'12,679"S); and, from north (56°33'13,231"W - 2°36'22,984"S), northeast (56°32'3,993"W - 2°38'54,774"S), northwest (56°38'5,299"W - 2°37'35,35"S), until southwest-south-southeast (56°38'46,944"W - 2°42'24,45"S).

The Micro-watershed is situated in the domain of the Settlement Project (SP) Amazonian Village, in the municipality of Parintins, Amazon State, Brazil.

2.2 Methodology

The diagnosis was developed by a participatory approach. The local people involved were from the seven communities that constituted the Polo 07 (*Bom Socorro, Nazaré, Paraíso, N. S. das Graças, Santa Fé, Boa Esperança, Toledo Pizza-Vista Alegre*), specially the first ones with direct access to fluvial net of *Zé Açu* Micro-Watershed.

Therefore, the methodology applied used the following supports:

a) The *cognitive maps: They were* used to identify the problem-situations that affect direct and indirectly the *Zé Açu* Watershed and family farmers' *way of life*.
   The choice of this technique (cognitive maps) is based on Cosgrove [13] and Nogueira [14], who argue in favor of stimulating people's perception to obtain the knowledge of a certain place, as a participatory diagnosis. Tuan [15] said that native people of a certain place *has a complex perception of the environment because they are part of it, sharing local myths and values. A cognitive map belongs to the field of* Phenomenological perception. In this case, the *cognitive map* allows credibility on data gathering, and integration researcher-local people.
b) The field work from 2010 to 2012: identification of fluvial channels with gullies, the clogging of first order channels and the longitudinal profile considering a process of sedimentation.
c) Geographic Information System (GIS): spatial data were gathered and stored in a geographical database, mainly the map of land use and occupation of the *Zé Açu* Micro-Watershed [16] and Satellites Images/Spectral waves TM/ LANDSAT-5 (orbit/point 228/062 and 229/062, August 2010 and 2011).

3. RESULTS AND DISCUSSION

The main findings of the performed diagnosis was the inadequate occupation and use of the land. This caused environmental impacts in the drainage basin such as the scarcity of water in the drought period, pluvial erosion, clogging and sedimentation.

Several factors can be related to the origin of the present problems: one of them, which can be considered as a central role, was the creation of the SP in 1988 as a land reform goal of the Brazilian's Government. Until 1987, the occupations were spontaneous and at a very low rate, however, when the SP was coming the drainage basin surface was divided in parcels-which were donated to traditional farmers [17]. Some years ago, many of this plots were sold to the same people, causing land concentration with medium to large scale activities inside there. The Table 1 shows how the lands had been occupied, initiating in the settling of 1986 (before the creation of SP) and after two and half decades (in 2010).

The Table 1 shows how much the *Zé Açu* Micro-watershed is affected by the suppression of the vegetation, and its substitution by extensive livestock farming (bovine and buffalo).The environmental impacts mapped by the family farmers and confirmed by the *filed true* are held in the area of permanent preservation (headwaters and hillslopes of river channels), where cattle can be found (Fig. 1).

The development of livestock farming occurs on dystrophic yellow oxisoils. There, the relief is not plain, presenting elevations with several hills lopes because of the river basin design. The

Table 1. Zé Açu micro watershed: Temporal evolution of the land use and occupation (1986 - 2010)

Land use categories	1986		1997		2005		2010	
	Area (km^2)	(%)	Area (km^2)	(%)	Area (km^2)	(%)	Area (km^2)	(%)
Family agriculture	27,991	22,05	36,52	28,77	17,150	13,51	36,562	28,81
Farmyard	1,759	1,39	0,67	0,53	24,280	19,13	9,292	7,32
Original forest	75,760	59,69	46,49	36,63	44,310	34,91	36,433	28,70
Hydrography	11,184	8,81	11,184	8,81	11,184	8,81	11,184	8,81
Pasture	10,230	8,06	32,06	25,26	30,000	23,64	33,453	26,36
Total	126,924	100	126,924	100	126,924	100	126,924	100

growth of this kind of activities is perceptible, from about 10 thousand km^2 of pasture and almost two thousand km^2 of farmyard in 1986, to more than 40 thousand km^2 destined for livestock farming (33,453 km^2 of pasture plus 9,292 km^2 of farmyard) in 2010.

The family agriculture is the second more developed activities in the interfluve area. They preferred plain topographies, distant form river and closer to roads and highways (Fig. 1), where the land preparing can be made with simple instruments such as machetes, hoes, ox-wagon, ax and some locally known artifacts as cambito [16].

The intense erosions gullies-like at *Zé Açu* Micro-watershed is due to deforestation: soils became exposed and susceptible to rainfall impacts, besides the bovine and buffalo trampling and soil compaction. The greatest gullies are located in twelve tributaries, distributed in three river channels. They affect directly their affluent and subaffluents (Fig. 2).

The clogging is located in the tributaries' borders and also in the main stream channel between its upper and mid-course. The colmatation process was recognized in two first order tributaries at the upper river.

The elevated rates of sediment concentration (Csts) and charges of transported sediments (Qsts) are correlated to the presence of bovine livestock in the Permanent Preservation Areas (*Áreas de Preservação Permanentes* - APP) in river banks. The environmental impacts seemed more serious in the period of fluvial ebb, when the suspended sediments rate makes the water change its color and density on the river bed. These changes prejudice the ecosystem functions and environmental services [16].

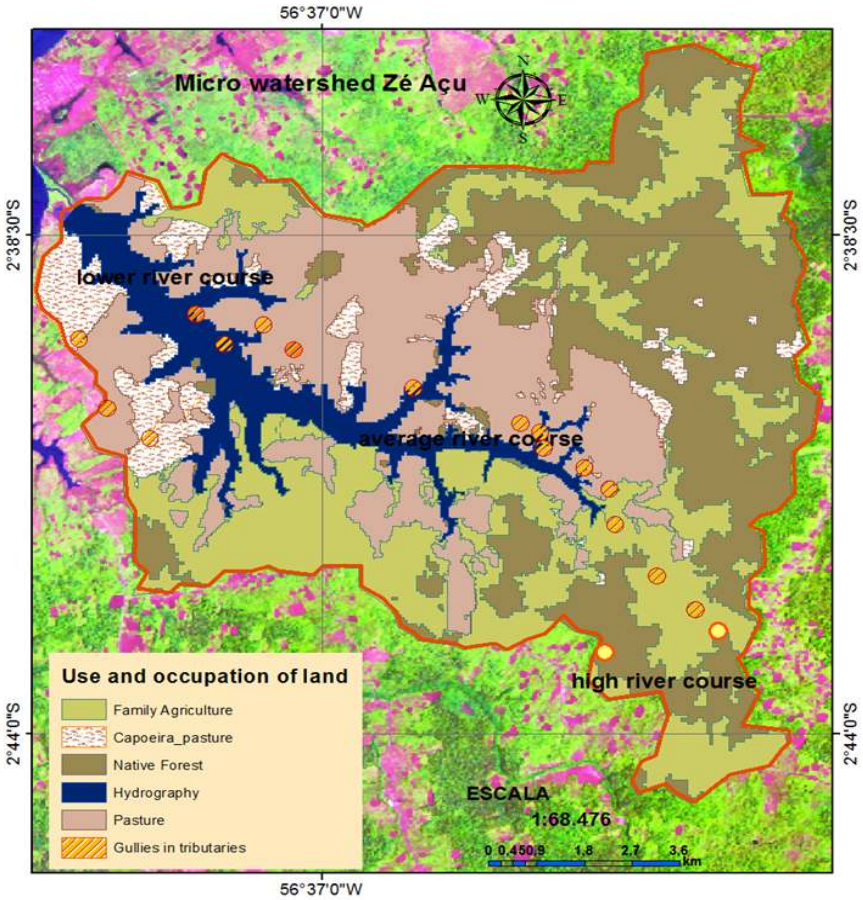

Fig. 1. Classes of land use, occupation, and tributaries rivers with gullies at Zé Açu micro watershed

Source: Org. Pacheco [16]

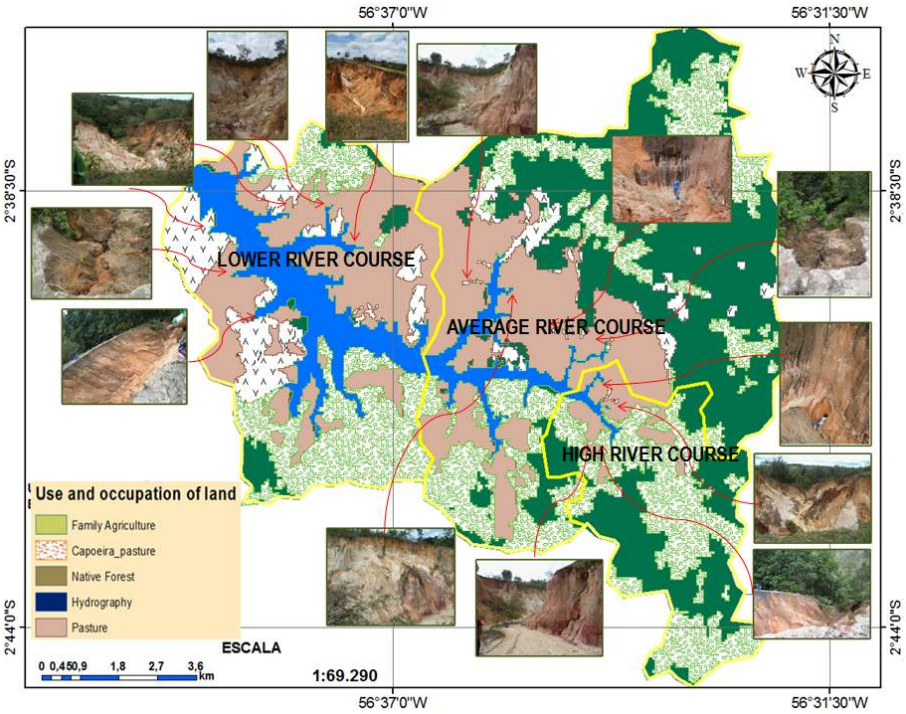

Fig. 2. Mosaic of the Zé Açu micro-watersheds with the drainage network and the location of gullies

Source: Org. Pachêco [16]

In thsoe places where family agriculture is found don't present gullies. This result may due because even though there had been deforested, soilare not exposed, due to the traditional way of working (pieces of fallow, spontaneous gardens, use of simple tools). Another factor of less degradation regarding the cultivation of this productive system is its geographical location. Family agriculture is not practiced nearby the rivers; they do occur by the extension of the *Boa Esperança* and *Santa Fé* roads and highways to get facilities to leave the agricultural production by roads until the main stream, at the lower course of *Zé Açu* Micro-watershed.

4. CONCLUSIONS

i) In summary, the anthropic impacts on the fluvial environment of Zé Açu Micro-watershed can have two scopes: Regarding the vulnerability of the *Zé Açu* Micro-watershed focused on its *fluvial environment:* its upper streams concentrate most of the impacts: an increase on the edges of the river banks and the elevation of its bed, by cords of sand deposit. These changes are leading to the beginning of a process of "strangulation" between the upper course and the mid-course, which will develop a *new* fluvial metabolism. This new scenery represents the on-going hydric system adjustment with prejudice to local communities. Natural systems are dynamic, and they can evolve to new stable levels. Nevertheless, it should be recognized that the intensity of the anthropic interventions is promoting changes in the fluvial morphology and dynamics, with different types of losses (decrease of the aquatic fauna and its diversity, reduction of the *Igapó* Vegetation, diminution of water quotas, among others).

ii) Regarding the "fluviality" and the *way of life:* the 416 families are strongly impacted, because they are dependents of *igarapés* and rivers by the ecosystem services that supply them (navigation, communication, alimentation, recreation). In the periods that water becomes scarce in the river, at least 3 months of the fluvial ebb period, if the water quota/vertical section becomes

more and more lower the fluvial transportation becomes impossible, affecting their economy, culture, and social relationships. Even their health can be affected because of water's lack of drinkability.

In this case, this study could show how nature and human process are interconnected, and some anthropic activities can give back prejudice to the humans themselves. When people are concerned to this cause-effect framework, they may realize the necessity of conducting actions and critical attitudes regarding their *spaces* as a place of living and also the importance of searching for the solutions by their own.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Aguiar FEO. Elementos constituintes e fatores influenciadores no clima da Amazônia. In: Rebello A. (Org.). Contribuições Teórico-metodológicas da Geografia Física. Manaus: EDUA/ Universidade Federal do Amazonas. 2010;(1):155-192. (Portuguese)
2. As Alterações Climáticas em Manaus no Século XX. Dissertação (Mestrado). Departamento de Geografia, Instituto de Geociências, Universidade Federal do Rio de Janeiro; 1995 (Portuguese).
3. Seixas IM, Pinheiro ES. Sensoriamento remoto aplicado à análise chuva-vegetação na Amazônia Central. GEOUSP – Espaço e Tempo. São Paulo. 2014; 18(2):635-649.
4. Fisch G, Marengo JA, Nobre CA. Uma revisão geral sobre o clima da Amazônia. Revista Acta Amazônica. 1998;28(2):101–126. abr/jun (Portuguese).
5. Salati E, Dall'olio A, Matsui E, Gat JR. Recycling of water in the Amazon basin: an isotopic study. Water Resource Research. 1979;15(5):1250–1258.
6. O Clima Atual Depende da Floresta - Cap. I . In: Salati E, Junk WJ, Shubart HOR, Oliveira AE de (org.). Amazônia: Desenvolvimento, integração e ecologia**.** São Paulo: Brasiliense/Brasília: Conselho Nacional de Desenvolvimento Científico e Tecnológico - CNPq. 1983;15-44. (Portuguese)
7. Molion LCB. Amazonia rainfall and its variability. In: Bonell M, Hufschmidt MM, Gladwell JS (eds.). Hydrology and water management in the humid tropics. International Hydrology Series, Cambridge University Press, Cambridge, Reino Unido. 1993;99–111.
8. Tucci CEM, Hespanhol I, Cordeiro Neto O de M. A gestão da água no Brasil: Uma primeira avaliação da situação atual e das perspectivas para 2025. Relatório para GWP; 2000. Available:http://rhama.net/download/artigos/artigo30.pdf (Accessed 12 March 2012)
9. Mello CR de, Lima JM de, Silva AM da, Lopes D. Abstração inicial da precipitação em microbacia hidrográfica com escoamento efêmero. Revista Brasileira de Engenharia Agrícola e Ambiental**,** Campina Grande. 2003;7(3):494-500. set./dez.
10. Corrêa AMA. Coluna do prof. Altir Corrêa: Prejuízos com as perdas de solo nas áreas agrícolas*;* 2003. Available:http://www.cnps.embrapa.br/search/planets/coluna14/coluna14.html (Accessed 21 de January 2014)
11. Bertoni J, Lombardi_Neto F. Conservação do solo. 4. ed. São Paulo: Ícone; 2005. (Portuguese)
12. Fearnside PM. Desmatamento na Amazônia: dinâmica, impactos e controle. Acta Amazonia. 2006;36(3):395-400 (Portuguese).
13. Cosgrove D. Introduction: Mapping meanings. In: Cosgrove D (org.) *Mappings.* London: Reaktion Books. 1999;1-23.
14. Nogueira ARB. Percepção e representação gráfica: A "geograficidade" nos mapas mentais dos comandantes de embarcações no Amazonas. Manaus(AM): EDUA-UFAM; 2014 (Portuguese).
15. Tuan Yi-Fu. Topofilia: Um estudo da percepção, atitudes e valores do meio ambiente, (Tradução de Lívia de Oliveira) Londrina: Eduel; 2012 (Portuguese).
16. Pachêco JB. Uso e ocupação da terra e a sustentabilidade dmbiental da dinâmica

fluvial das microbacias hidrográficas Zé Açu e Tracajá na Amazônia Ocidental. Tese (Doutorado). Pós-Graduação em Desenvolvimento Sustentável, Centro de Desenvolvimento Sustentável, Universidade de Brasília, Brasília (DF). 2013;269 (Portuguese).

17. PRA-MDA/INCRA - Ministério do Desenvolvimento Agrário/Instituto Nacional de Colonização em Reforma Agrária. Plano de Recuperação do Projeto de Assentamento Vila Amazônia MDA/INCRA/COOTEMPA - Parintins (AM.); 2007 (Portuguese).

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