

## SOIL COLLAPSE IN TECHNOGENIC PLAIN: THE CASE OF THE SÃO JOÃO BATISTA NEIGHBORHOOD IN ABAETETUBA-AMAZON-BRAZIL

*Érika Renata Farias Ribeiro<sup>1</sup>; Claudio Fabian Szlafsztajn<sup>2</sup>; Pedro Aníbal Beatón Soler<sup>3</sup>; Walber Lopes de Abreu<sup>4</sup> & Carlos Eduardo Pereira Tamasauskas<sup>5</sup>*

**ABSTRACT** – This article aims to analyze the collapse event that occurred in the urban landscape of the city of Abaetetuba. The study was conducted using the Peggia classification (1996) on technogenic plains that emphasizes the risks in this landscape, as well as consultation to the CPRM Report (BRASIL, 2014), which enabled the causes of the disaster to be understood. The surveys were conducted through fieldwork, interviews with the people of the neighborhood, photographic records, and map preparation. We noticed that the urban landscape of Abaetetuba presents risks due to the grounding of its plain with several unsuitable materials (solid waste, debris, building debris, seeds, sawdust, etc.). When it comes in contact with humidity, that type of landfill becomes fragile, representing a threat. Thus, we can conclude that the disaster resulting from soil collapse in the São João Batista neighborhood occurred due to several factors, including: the inappropriate material used to ground the site; the weight of the constructions, plus the loads resulting from the use; the flow of heavy vehicles; the existence of a depression in the original soil near the point of collapse; and the absence of a study corresponding to the soil characteristics that would have ensured the decision on the appropriate foundation for this type of soil.

**Keywords** – Soil Collapse. Technogenic Plain. Abaetetuba.

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1) Universidade Federal do Pará, Doutoranda do Programa de Pós-Graduação em Geografia/PPGEO/UFPA, Rua Augusto Corrêa, 1, Guamá, Belém-PA, 66075-110, erikarpfarias@gmail.com, 91982166158.

2) Universidade Federal do Pará, Docente do Programa de Pós-Graduação em Geografia/PPGEO/UFPA, Rua Augusto Corrêa, 1, Guamá, Belém-PA, 66075-110, ioseselesz@gmail.com, 91981569569.

3) Universidade Metodista de Piracicaba, Docente da Faculdade de Engenharia, Arquitetura e Urbanismo/UNIMEP, Rodovia do Açúcar, Km 156, Taquaral, Piracicaba-SP, 13400-911, pedrobeaton@gmail, 19981890400.

4) Universidade Federal do Rio Grande do Sul, Doutorando do Programa de Pós-Graduação em Geografia/POSGEA/UFRGS, Av. Bento Gonçalves, 9500, Agronomia, Porto Alegre-RS, 91540-000, walberlopesabreu@gmail.com, 91993849103.

5) Centro Gestor e Operacional do Sistema de Proteção da Amazônia/Censipam, Av. Júlio César, 7060, Val de Cans, Belém-PA, 66617-420, ctamasauskas@gmail.com, 91982572807.

## 1 - INTRODUCTION

This study aims to analyze a problem that occurs in many Brazilian cities related to the spontaneous growth in the natural risk area, resulting in the germ of vulnerability (Veyret, 2013). This situation occurs in the neighborhoods established on the banks of the Maratauíra River in the city of Abaetetuba, where the landscape is associated with the watercourse and the presence of occupations on the floodplain. This area was grounded over the years, and can now be considered a technogenic plain<sup>6</sup> due to intense change caused by human action (Ribeiro, 2017).

We consider that a mischaracterization of the floodplain can cause a collapse in the soil, due to the grounding of the area with various materials such as solid waste, debris, construction debris, açai seeds, sawdust, and others. This type of landfill represents a threat to those who inhabit these spaces, and can generate environmental disasters.

In the city of Abaetetuba, four environmental collapse events occurred, all in neighborhoods that developed on the banks of Maratauíra River—two registered by the Brazilian Geological Service CPRM (2014), and two learned from the information obtained through interviews with residents. Facing this fact, we understand that the most striking case occurred in the neighborhood of São João Batista, which requires study of the risk landscape to identify existing problems in the neighborhood. Thus, this article aims to analyze the soil collapse event based on the classification formulated by Peloggia (1996) on the technogenic plain, consequently allowing for a discussion that can subsidize environmental management and municipal urban planning.

## 2 - METHODOLOGICAL PROCEDURES

To develop this study, we used the CPRM (2014) report, which identifies areas of high and very high risk of mass movement and flooding in the city of Abaetetuba. In addition, a relationship of this event was elaborated with the classification of soils according to Peloggia (1996). In order to understand the landscape and its transformations, fieldwork was carried out with interviews with five older residents, photographic records, and mapping of the study area from the QuickBird satellite image.

The article is structured as follows: initially, we characterize the study area and its occupation process; then, we discuss the results achieved; and finally, we present the final considerations.

## 3 - CHARACTERIZATION OF THE STUDY AREA

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<sup>6</sup> This refers to the impact of human action on the environment, which is related to the perception of expressiveness of changes brought about by man on Earth's surface and can be compared, in terms of magnitude, to changes of natural origin (Peloggia, 2006).

The municipality of Abaetetuba belongs to the mesoregion of the northeast of Pará State and to the micro-region of Cametá. It presents an urban landscape marked by the presence of the floodplain of the Maratauíra River, which is affected by the tides—especially in January, February, and March, where part of streets and backyards are affected by floods (Ribeiro, 2017).

Ribeiro (2017) observes that the populations living in the floodplain of the Maratauíra River experience situations related to flooding each year, which represents a health hazard due to exposure to waterborne diseases. In addition, collapse episodes in the soil could potentially occur, due to the type of landfill used, such as those composed of organic matter and rubble.

The present study analyzes the São João Batista neighborhood because it is the one that best represents the existence of the technogenic plain, since it presents a landscape marked by a collapse in the soil that occurred in 2014. The referred neighborhood suffered spontaneous occupation processes in the floodplain area, with a large volume of landfill made up of inappropriate materials; this landfill covered depths of 1 to 6 meters, which reveals the process of formation of the technogenic plain.

## 4 - RESULTS AND DISCUSSION

### 4.1 - Analysis of Technogenic Plain and the collapse of the São João Batista neighborhood: Subsidies for Environmental Management

We consider that the area of study corresponds to what Peloggia (1996) identifies as being the result of the technogen, classified as another period in the geological scale in which man is the modeler of the landscape. "Therefore, to define an origin linked to the activity of man, it would be more convenient to use the term technogenic" (Peloggia, 1996, p. 20).

These soils resulting from the technogen denote danger, and are considered as catastrophic (Peloggia, 1996). According to the author's classification, there are at least four of these types of soil, consisting of:

- 1) Urbic Materials: these are urban waste earth materials containing artifacts manufactured by modern man, often in fragments, like bricks, glass, concrete, asphalt, nails, plastic, various metals, crushed stone, ashes, and others (for example, from building demolition debris).
- 2) Garbage Materials: these are deposits of detrital material with organic waste of human origin, and which, although containing artifacts in much smaller quantities than that of the urbic materials, are sufficiently rich in organic matter to generate methane under anaerobic conditions.
- 3) Spoil Materials: materials excavated and redeposited by earthworks in open pit mines, highways, or civil works. They contain few artifacts, and are identified by the "non-natural" geomorphic expression or by textural and structural peculiarities in their profile.
- 4) Dredged materials: materials from the dredging of watercourses and commonly deposited in dikes in topographic dimensions superior to those of the alluvial plain.

In urban space, this type of soil (technogenic origin) is found mainly in peripheral areas; when added to the precarious infrastructure, it creates an environment of risk for the population. In the Amazon, many cities have expanded with riverbank landfills, such as the city of Belém, which (similar to Abaetetuba) landed many floodplains, generating plains with technogenic characteristics.

Thus, we consider that the anthropic action is responsible for the alteration in the physiology of the landscape through the creation of the technogenic relief, establishing an environment of risk due to the threat of collapse. The grounding of the plain of the São João Batista neighborhood occurred with the use of various materials (açai seeds, ceramics, garbage, sawdust, tree branches, plastics, etc.) that can be classified, according to Peloggia (1996), as garbage and urbic soils.

Grounding in natural flood risk areas associated with social vulnerability can lead to disasters, and they become areas of geological risk due to the formation of technogenic soil. The disaster of the São João Batista neighborhood is related to the type of material used to ground the plain, which is already an area susceptible to erosive processes. It is important to emphasize that urban occupation, and its peripheral expansion specifically, introduce disturbing elements of topography by developing specific forms of erosion and modeling, such as "the grounding 'in sheet' in the plains." (Peloggia, 2005, p. 26).

This transforming action of the landscape's physiology by mankind is what Peloggia (2005, p. 24) considers a "geotechnogenesis: transformation of the geological environment by man", characterized by the author as responsible for the erosive potential, due "to the constant remobilization of material by overlapping the channels' margins, due to the situation of hydraulic instability" (Peloggia, 2005, p. 29).

Peloggia's (1996) analysis of the technogenic, and specifically the plains of technogenic origin, can be referenced to explain the type of relief that was built during the urban occupation process of the city of Abaetetuba, which is responsible for the risks in the urban landscape.

In studies carried out by Ribeiro (2017), the risk map of the study area was constructed with consideration of hazards that are present in the technogenic plain (Figure 1).

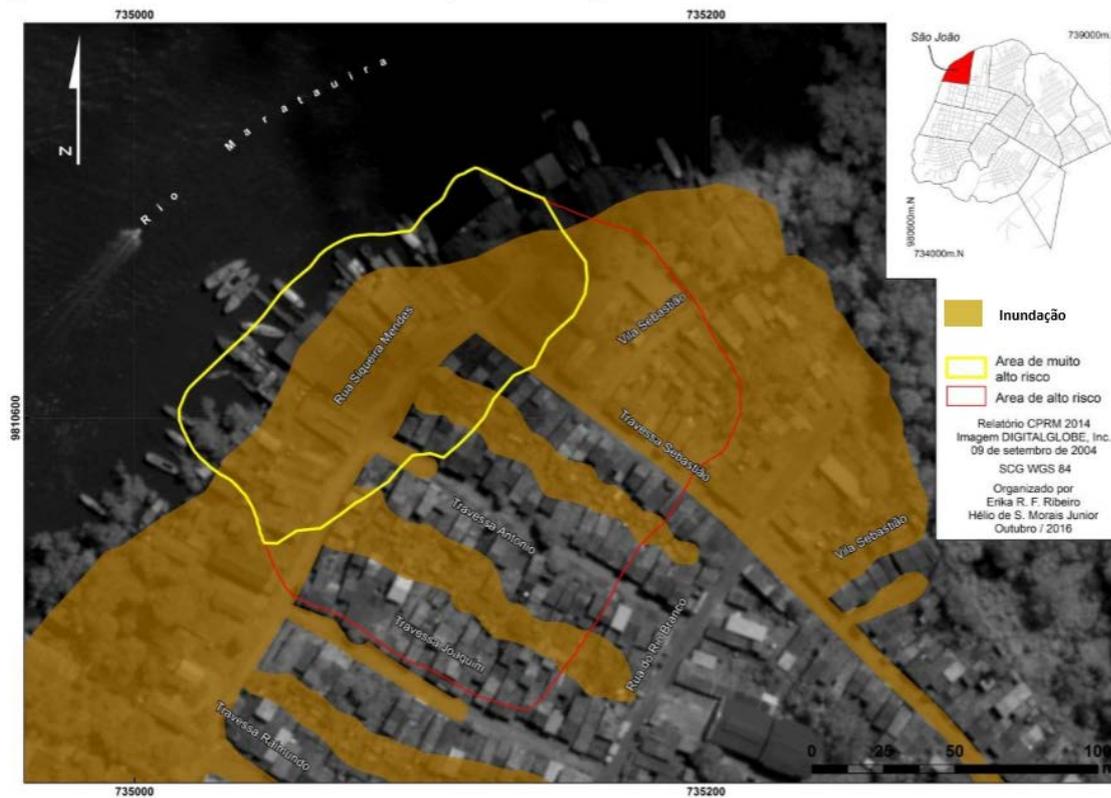


Figure 1 – Areas of Mass Movement, Soil Collapse and flooding. (Source: own authorship).

In the opinion issued by CPRM (2014) about the event occurred in the neighborhood of São João Batista, technicians classified the area as being high risk and very high risk concerning mass movements and flooding. According to a survey conducted in the field, 448 people were at risk.

Figure 2 demonstrates the consequences of the mass movement caused by collapsible soil, which is very sensitive to water, since the increase of humidity increases its saturation; as the area corresponds to a floodplain, the impact was intensified.



Figure 2 - Disaster occurred in the São João Batista Neighborhood on January 7, 2014. (Source: Raimundo A. C. da Conceição, 2014).

The material used to ground the plain was one of the factors that contributed to the disaster, because the weight of masonry buildings leaves the soil with less resistance. Another factor was the truck traffic on site, reported by the population as a harmful situation.

The analysis performed in the area by the CPRM (2014) found, through bathymetry data, a depression in the original soil in front of the point of collapse, information that was confirmed by local residents. In addition to all these damaging situations, another aggravating factor for the disaster was the problem of the foundations used in buildings, due to the absence of a corresponding study to the soil characteristics.

Due to the high and very high risk classification by the CPRM (2014), it was recommended to relocate the families that inhabited the area and to reforest the area with native species, making sustainable use possible.

Environmental management should consider regional particularities, requalifying risk areas and valuing the symbolic aspect of the landscape, which incorporates a connotation of immaterial appropriation by the inhabitants of a city that has a riverside identity.

## 5 - FINAL CONSIDERATIONS

The soil collapse in the São João Batista neighborhood occurred due to several technical factors, including: the material used to ground the site; the weight of the constructions, plus the loading from use; the flow of heavy vehicles; the presence of a depression in the original soil in front of the point of collapse; and the absence of a study corresponding to the soil characteristics that could have ensured an informed decision on the appropriate type of foundation to be used. Other factors—such as the precarious infrastructure, the low income of the population, and the lack of knowledge concerning the vulnerability caused by the construction of houses on a collapsible soil—are social problems that create favorable conditions for the occurrence of these events.

The risky landscape in the São João Batista neighborhood presents an unstable picture that has resulted in an environmental disaster; this requires an emergency urban intervention by the local public power. The environmental degradation in the urban environment, along with the social vulnerability, exposes the population to situations of risk; this is a challenge to municipal managers, in the sense of seeking social and environmental sustainability.

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