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Environmental Analysis of Guamá River Floodplain, with Emphasis for Clay Mining in the City of São Miguel do Guamá (PA)

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***Abstract*—*The use of natural resources, in recent times, has intensified in exponential scale as well as their degradation, fostered by the inadequate management of the soil, water bodies and biodiversity. One of the most affected places by this dynamic is related to floodplain or lowland, since the vegetation suppression, present in this environment, is subtracted by anthropic actions through practices such as agriculture, urban construction and mining. This last one, in the municipality of São Miguel do Guamá, state of Para, occurs as a result of the extraction of clay, used from the manufacture of ceramics (bricks, tiles, etc.) to medicinal treatments. The approval of Federal Law No. 12,651 / 2012 allows mining activity in floodplain and Permanent Preservation Area (APP). Thus, the present study aims to analyze the recurrent environmental impacts in these areas, focusing on the Guamá river APP, inserted in the municipality of São Miguel do Guamá, by mapping the floodplain, APP and land cover in this area; identification of clay extraction sites; gauging the environmental impacts of extraction; quantify land cover; evaluate and propose measures to mitigate environmental impacts. Based on the results it can be concluded that floodplain forest suppression and fragmentation directly influence the provision of ecosystem services to the local population. The main factor of this loss is the change in land use and the activity of clay extraction along the lowland.*

***Keywords*— Natural Resources, Sao Miguel do Guamá, Permanent Preservation Area, floodplain, clay extraction.**

I. INTRODUCTION

The process of degradation of natural resources, as a result of land use dynamics, such as inadequate management of soil, water and biodiversity, has been a cause of global concern in recent decades (BRASIL, 2019).

The transformation of forests for agriculture, livestock and mining, as well as urban-industrial activities has had a negative impact on terrestrial and aquatic ecosystems. This change compromises the functioning and natural regulation of the environment, therefore its ability to supply ecosystem (SE) and environmental (SA) services (BRAZIL, 2019).

According to MEA (2005) SEs are the benefits / improvements that humans derive from ecosystems. These include provision services (food and water); regulating services (erosion, climate, air, water regulation); cultural services (cultural diversity, educational and aesthetic values, social relations); and support services (soil formation, photosynthesis, nutrient and water cycling). But the SA, for Muradian et al. (2010), are defined as environmental benefits arising from intentional practices of society in the dynamics of ecosystems. In this way, ecosystem / environmental services have not only economic impacts, but also health and human welfare.

Among the various ways to protect and conserve the environment, the preservation of riparian forests (riverbank vegetation, streams, lakes, dams and springs) contributes to the construction of ecological corridors, recovery and maintenance of biodiversity in rivers, conservation of the hydrological cycle in the river basins, hindering the erosion process of river banks and siltation of their beds, besides helping in the biological balance of pests and improving the quality of life (BONONI, 1989). Due to its important role for environmental balance, the riparian forest is considered by the Brazilian Forest Code as Permanent Preservation

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Area (APP), its main objective is to preserve fragile places such as riverbanks, springs, slopes and hilltops (BRAZIL, 2012).

However, not only the riparian forests present in the above mentioned sites deserve protection, but also the preservation of the vegetation along the floodplain (lowland) has an important role in establishing the balance of a watershed. Benatti et al (2005, p. 24) define thefloodplains as “areas marginal to water streams, periodically flooded, either by tidalinfluence or by river overflow due to rain”. Floodplains areconsidered apriority ecosystem for conservation due to their high biodiversity and offer benefits to society, such as: aquifer recharge, water storage and purification, flood control and food in this habitat (ROLON et al., 2006). However, over the years, vegetation suppression has been observed in these environments, substantially affecting the energy balance. Typical vegetation in these areas has been replaced by crops intended for agriculture, pasture and city expansion without proper planning (LEITE, 2013).

In floodplain, in APP sites, mining activities may occur. In the economic vector, these activities provide income generation through the use of raw materials in industrial sectors. In the social context, there is the generation of jobs that the sector represents, in addition to tax collection and economic circulation (SANTOS, 2014). Some ores such as clay are used directly in construction, ceramics and health care.

However, like any other economic activity, unplanned mining results in negative impacts on the environment, such as subtraction of plant and animal species, lake formation, and erosion (PARA; FIBGE, 1995). However, according to art. 8 of the New Forest Code, Federal Law No. 12,651 / 2012, the intervention or suppression of vegetation in APP will only occur if there are assumptions of public utility, social interest or low environmental impact (BRAZIL, 2012).

In the municipality of Sao Miguel do Guamá, state of Para, mining activity is mainly related to the extraction of clay, since its use ranges from the manufacture of ceramics (bricks, tiles, vases, among others) to medicinal treatments. Its formation derives from the alteration of some rocks and can be found near the rivers, has varieties in their colors, and can be white and red. This material is a constituent part of the soil next to silt and sand and has particles with high moisture retention capacity. When aggregated with other compounds, clays give rise to extremely fertile soils (JACOMETI, 2011).

The flexibility of Federal Law No. 12,651 / 2012 allows, through mining activity, greater possibilities for soil degradation and vegetation cover, producing negative impacts on APP and floodplain, thus modifying existing ecosystem and environmental services. Thus, analyzing the dynamics of land use and land cover is essential to understand the impacts occurring in the floodplain, focusing on areas protected by legislation (APP), because, although there is the presence of mining activity, it ispossible to achieve balance of theecosystem for thesustainable use of existing natural resources.

II. STUDY AREA

2.1 General Characterization

For this research we took as study area the municipality of Sao Miguel do Guamá (Fig. 1), located in the Intermediate Region of Castanhal and Immediate Region of Castanhal, according to the new regional division of the Brazilian Institute of Geography and Statistics (IBGE). , and in the Northeast Paraense Mesoregion and GuamáMicroregion according to the previous division. The municipality has as the southern limit, the Guamá River (Fig. 2), where its floodplain and APP will be the focus of the environmental analysis of the research, considering the external interference from the economic activities developed in the municipality in question.

In 2010, the municipality of São Miguel do Guama had 51,567 inhabitants distributed over 1,100,175 Km2 in its territory, and according to the estimate made in 2019, its approximate population is 58,986 people (IBGE, 2010). In the seventeenth century, the period of its colonization the main economic activity revolved around the vegetal extraction of fruits and woods, trade, agriculture and subsistence livestock. Until the 1960s, its main route of locomotion/interconnection with other municipalities and rural villages was through the Guamariver. From the second half of the twentieth century onwards, the logging and mining activities began to be highlighted, with the extraction of clay. In 1970, the manufactured companies were the ones that consumed the most labor generating jobs and income in the municipality. Only in 1980, the ceramic activity stood out in the local and state economic scenario, when there was the installation of industrial production units (CORDOVIL, 2010).

According to the National Department of Mineral Production, the municipality of São Miguel do Guamá is home to the main ceramics district in the north of the country, and potteries correspond to a percentage of 60.7% of the companies housed in its territory (DNPM, 2010).

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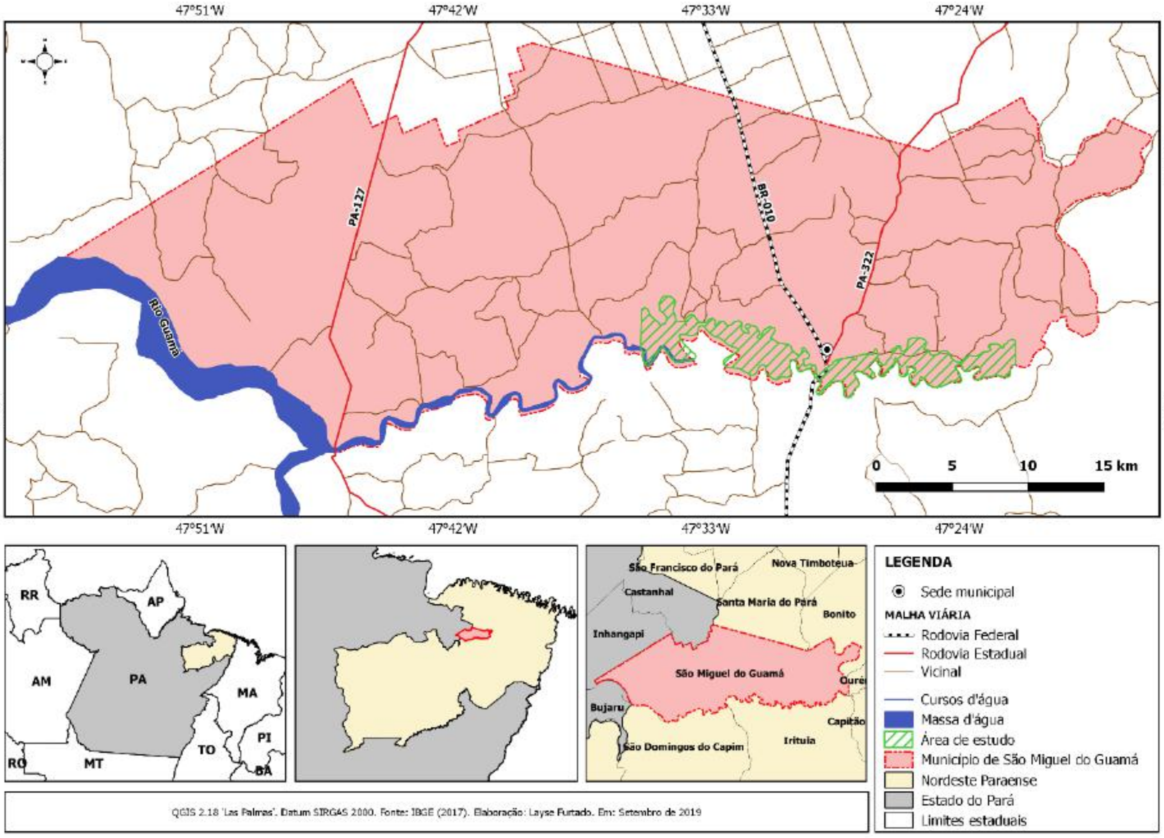

Fig. 1: Location map of the municipality of Sao Miguel do Guamá / PA.

Fig. 2: Photographic record of the Guamáriver between the municipalities of São Miguel do Guamá and Irituia.

2.2 Physical-Environmental Characterization

The study area is inserted in a floodplain (floodplain) ecosystem, in which there is a period of ebb during the less rainy season between June and December, when the volume of the Guamá river falls; and another of flooding in the rainy seasonbetween January and May, characterized by the increase of waters, which overflow cause flooding of marginallands in different degrees of intensity (BENATTI, 2016). The Alluvial Dense Ombrophilous Forest (or floodplain forest) (Fig. 3), whose vegetation occurs along rivers and floodplains, is usually less diverse than the adjacent dryland, and houses animals and plants adapted to seasonal hydrological conditions (KALLIOLA et al., 1993). The lowest diversity occurs because few species have morphophysiological mechanisms that tolerate the seasonal rhythm of flooding (SILVA et al., 1992). The lowest diversity occurs because few species have morphophysiological mechanisms that tolerate the seasonal rhythm of flooding (SILVA et al., 1992).

Fig. 3: Photographic record of the vegetation present in the floodplain.

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A vegetation cover characterized mainly by secondary forest (Fig. 4), result of intense suppression of native forests. On the other hand, the interior of the vegetation with alluvial Herbaceous lacustrine vegetation, remnants of the original cover, can also be found in the marginal portions of the Guamáriver.

The main hydrographic accident in the municipality is the Guamáriver, which borders the municipalities of Irituia, São Domingos do Capim and Bujaru. The right bank portion of the Guamá river is cut by several tributaries, including the Cupera, Matupireteua, Ajuaí, Crauteua, Aracuí, Urucuri streams. The topography has a soft relief, showing few oscillations. In the municipality the altimetric quotas have little amplitude, average of 20 meters above sea level, and the maximum quota around 73 meters, with minimum around 10 meters.

Geologically, cohesive sandstones, named "Guamá Sandstone", appear in the vicinity of the municipal headquarters, characterized by well-rounded, well-selected medium-sized quartz-sandstone layers with a high degree of textural and compositional maturity, probably of Silurian age (MARTINS, 2019). Its geomorphological feature is characterized by the retouched flat surfaces. The eastern portion of the municipality consists of rocks from the Gurupi group, dated from the Precambrian, formed by phyllites, shales and metavolcanic, and may find quartz and auriferous veins. In smaller quantities it is possible to find rocks of the Maracaçumé Complex present in the quarries of the Bragantina region. Alluvial deposits are located on the banks of the Guamá river and tributaries, typical of a River Plains environment (DIAGNOSTIC REPORT FOR PREVENTION ACTIONS, 2017). The Barreiras Group, more specifically the clayey sandy facies, represents the most prominent geological unit in the municipality, consisting of clayey layers, and few amounts of sand are generally incoherent, gray to yellowish, sometimes variegated (GOES, 1981; KOTSCHOUBEY et al., 2017). This group underpins the geomorphological compartment named by the Bragantina Zone Tablelands, formerly named Lowlands of the Amazon by Barbosa and Novaes Pinto, in 1973 (DANTAS and TEIXEIRA, 2013).

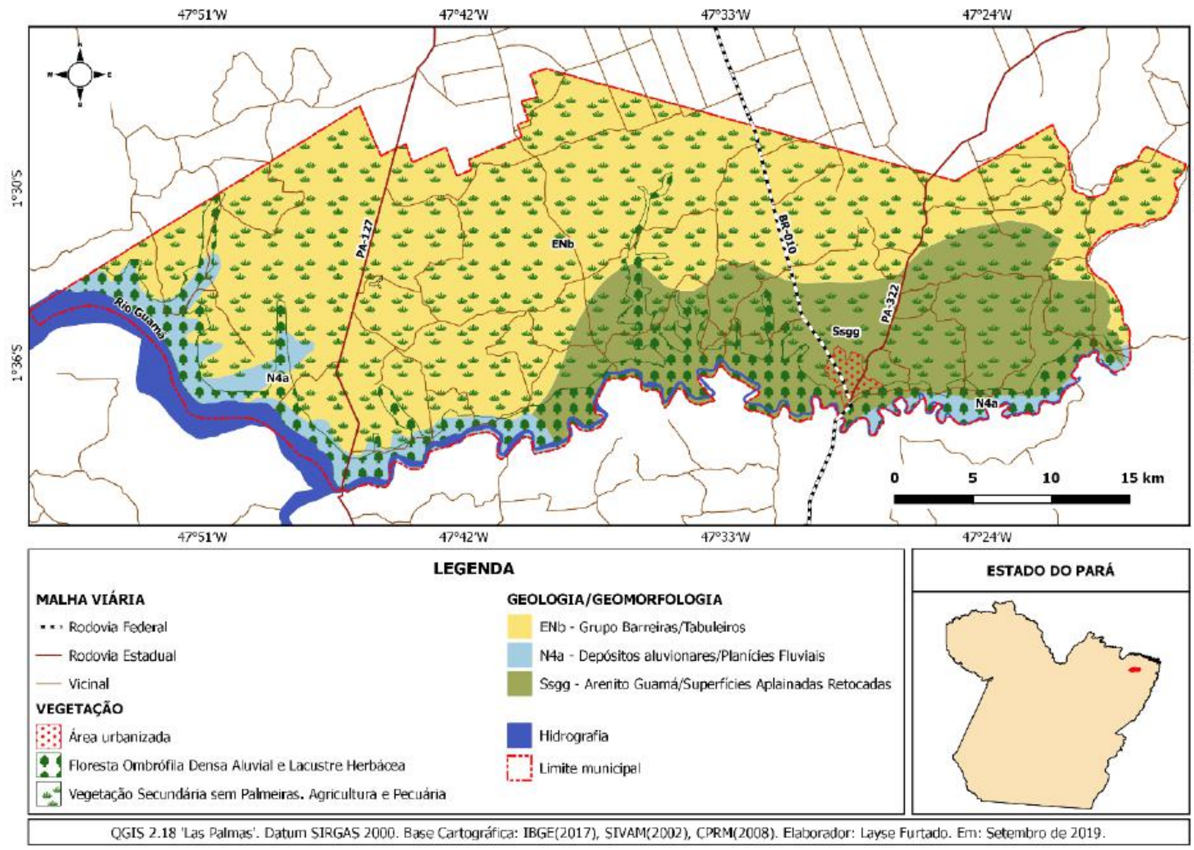

Fig. 4: Physical and environmental map of the municipality of Sao Miguel do Guamá / PA

III. MATERIALS AND METHODS

Initially, it was necessary to consult specific studies and current legislation, collect primary and secondary data through field visits and digital platforms, respectively, in order to better understand the processes of use and occupation. on the floodplain and on the Guamá river APP.

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Next, the other materials and methodological processes used in this research will be presented.

3.1 Cartographic Database

To know the physical-environmental aspect of the study area, it was necessary to consult and acquire the cartographic data available in the digital collections of the Brazilian Institute of Geography and Statistics (IBGE), Amazon Surveillance System (SIVAM), Mineral Resources Research Company (CPRM), on a scale of 1: 250,000, as well as the National Department of Mineral Production (DNPM), which was adopted for the identification of mining areas through DNPM-registered mining processes, available on the System's online platform Geographic Information Service - SIGMINE. This information was collected in July 2019, at the same time as the field visit, with the intention of generating more accurate results in the identification of active and inactive caves. All information available on SIGMINE is official and used according tothe frequency of each institution, thus being updated daily at 24h.

Data related to geology, geomorphology, vegetation and mining areas were spatialized in a Geographic Information System (SIG) environment, program QGIS 2.18. These systems, when related to other technologies, can acquire, store, manipulate, simulate, and model geographic data, helping to interpret the natural and anthropogenic processes that occur on the earth's surface over the years.

To delimit the floodplain it was necessary to use aerial photographs of the municipality sent by the CPRM virtual library. It makes available the first collections of the Geological Services of Brazil, as well as a collection of DNPM publications. This online platform includes a significant number of technical documentation, especially photocartographic, digitized and integrated in a search technology.

This online platform includes a significant number of technical documentation, especially photocartographic, digitized and integrated in a search technology. The nominal scale of the photos in black and white infrared film is 1:70 000 and the photo index is 1: 250 000. These two photographs have a 30% lateral and 60% longitudinal overlap, which helps in better interpretation of the images targets.

After obtaining the photos in the SIG environment, their georeferencingwas performed, by means of the recognition of control points in a 2B sentinel image, in order to start the floodplain vectorization.This image has a MultiSpectral Instrument (MSI) sensor with a spatial resolution of 20 meters and corresponds to June 30, 2018, available from the United States Geological Survey (USGS). Through it was possible to identify and vectorize the targets, with scale of 1:35 000, classified in: water mass, extraction area, anthropized area, natural fields, undergrowth and dense vegetation.

Finally, adjustments were made to the geometry of the Guamá river based on the Sentinel satellite image and the hydrographic vector file provided by IBGE. In view of the delimitation of the river channel, the buffer tool was used, inserted between the spatial operators belonging to the geoprocessing, to design the APP'saccording to the parameters established by law.

3.2 Fieldwork

The trip to the field was extremely important to validate the data collected in the laboratory and to verify the social and environmental aspects present in the study area. The *on-site* visitation is necessary as long astargets smaller than 20 meters in the satellite image cannot be identified and may be confused or generalized with other targets of similar spectral responses. Given this, this procedure allows to guarantee the reliability of digital data through reality in the field.

Throughout the area covered by the Guamá River, with the help of tools such as questionnaires, camera phone and Garmin GPS, it was possible to record some areas with environmental impacts in photographs, as well as to identify and collect geographical coordinates of the extraction sites of active and inactive clay.

After recognizing these sites, the visit was made at the Municipal Environment Secretariat (SEMMA) and the Municipal Finance Secretariat (SEFIN), with the purpose of understanding what are the mitigating measures adopted in the extraction sites and which are the main activities. prevailing economic conditions in the municipality.

IV. RESULTS AND DISCUSSIONS

The results presented here are divided into 3 stages for the environmental analysis of the floodplain and the Guamá River Permanent Preservation Area (APP). The first step is based on the mapping of floodplain, APP and land cover and their quantification. In the second stage, the clay extraction sites are identified and the environmental impacts of this activity are verified. And the last step was designed to evaluate and propose measures to mitigate environmental impacts.

4.1 Floodplain Mapping; Permanent Preservation Area (APP) and Land Cover and their Quantification

4.1.1 Floodplain mapping

In the study area, the floodplain contiguously follows the right bank of the Guamá river, has an area of 4,473 ha, approximately 24,700 km long and with a width ranging from 150 meters to 4 km, which can be covered by floods of the Guamá river and its tributaries.

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From the aerial photographs of the late 1970s it was possible to identify the primary vegetation, however, with the presence of small clearings of deforestation and / or flooded fields (Fig. 5). The beginning of these small anthropogenic changes in the landscape of the municipality was intensified due to the economic activities developed in the 70s and 80s with the logging and red ceramics, is last having greater significance in 1980 with the installation of industrial production units, remaining until nowadays.

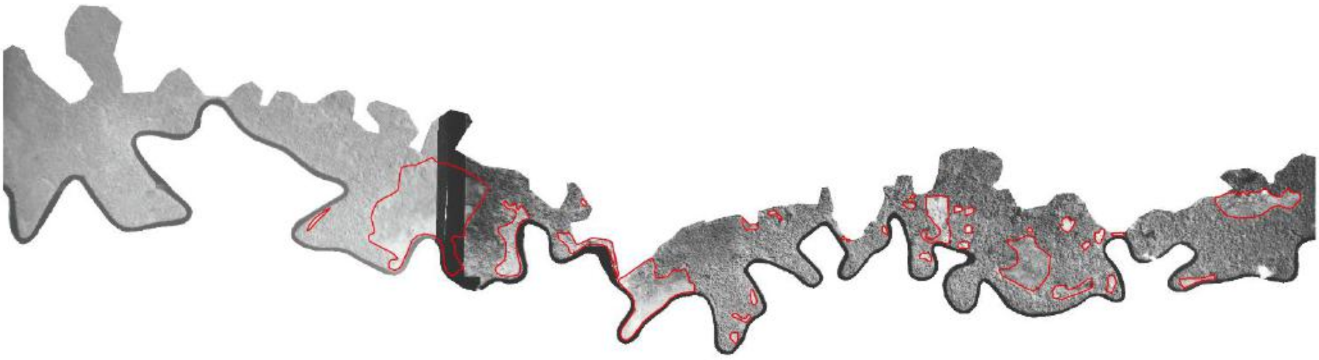

Fig. 5: Deforestation clearings and/or flooded fields on the Guamá river floodplain.

4.1.2 Permanent Preservation Area (APP) Mapping

To demarcate the Permanent Preservation Area (APP) of the Guamáriver, it was adopted by Law No. 12.727 of 2012, which determines an APP according to margin ranges of any perennial and intermittent natural watercourse, excluding ephemerals, since the edge of the regular bed chute. From this determination, the Guamá river vectorization process was carried out by means of satellite images and the IBGE hydrographic cartographic base, wherethe buffer tool was used to determine the distances stipulated by the forest code.

In the region under study, for the most part, the width of the river is between 50 and 200 meters, and only a portion, which has a physical boundary between the municipality of São Miguel do Guamá and Irituia, has a river width of over 200 meters, which guarantees a greater delimitation of the APP in this section. Given this, the Guamá river APP, in the study area, has a range of 100 and 200 meters, totaling an area equivalent to 529 ha. In some locations further east of the urban core, near BR-010, there is a significant presence of active and inactive clay extraction pits (Fig. 6) and fish ponds (Fig. 7) within the APP. Abandoned caves (Fig. 8) located in the region generate water accumulation, favoring the proliferation of disease vectors. Because they are adjacent to the Vila Sorriso and Patauateua neighborhoods, this situation is problematic from a social and environmental point of view.

Fig. 6: Photographic record of the clay extraction pit in the floodplain.

Fig. 7: Photographic record of the fish farming tank in an old extraction area.

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Fig. 8: Photographic record of an abandoned pit with possible proliferation of disease vectors.

It is noteworthy that intervention or plant suppression in these areas is only allowed in the hypotheses of public utility, social interest or low environmental impact provided by law. Conama Resolution 369/2006, regarding the possibility of mineral exploration in these areas, authorizes environmental agencies to intervene, provided that it respects the legal requirements in cases of public utility, for the activities of exploration and extraction of mineral substances. except sand, clay, gravel and gravel (BRAZIL, 2001).

Given this, the presence of clay extraction in the Guamáriver APP is supported by law, but it must be considered that there are clandestine clay extraction sites, in addition to the irregular expansion of extraction areas delimited by DNPM. This confirmation was possible thanks to the in situ visit and the help of technologies capable of imagining the region of interest.

4.1.3 Mapping of land cover and its quantification

Due to deforestation, changes in the vegetation cover of the municipality of São Miguel do Guamá are evident, with the suppression of much of the primary forest. Currently the municipality has predominance of secondary forests, with some remnants of primary vegetation, belonging to the Dense Forest of the Low Plateaus and Dense Forest of the Alluvial Terraces, this last located in the areas of influence (lowland) of the Guamá river and its tributaries, affected by flooding.

As illustrated in Fig. 9, land cover in this region was classified into five categories, namely: pioneer vegetation with river and / or herbaceous lake influence (1,010 ha), characteristic of wetlands / natural fields; alluvial dense ombrophilous forest (2,283 ha); secondary vegetation, temporary culture and pasture (175 ha), result of economic activities (livestockand agriculture); mining area (470 ha), where clay extraction pits are present; and the urbanized area (84 ha), corresponding to the urban core, more specifically the edge of the city and its surroundings.

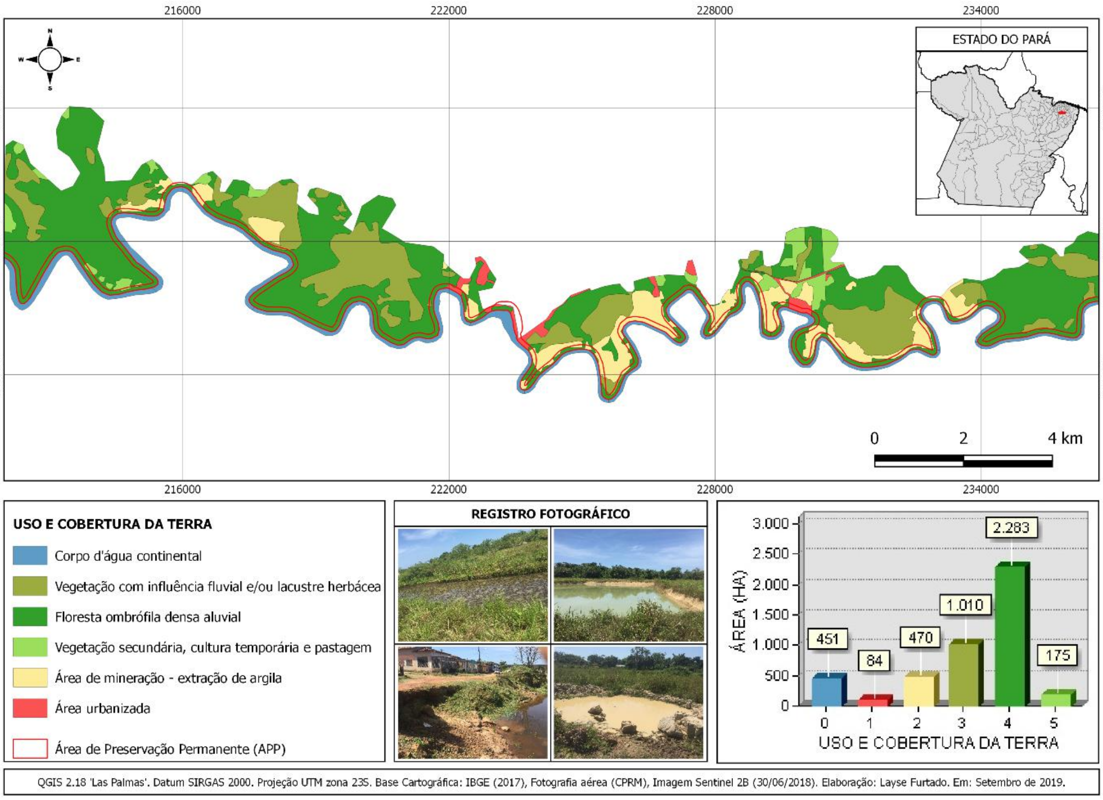

Fig. 9: Map of land cover in part of the flood plain in the municipality of São Miguel do Guamá -PA.

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Along the floodplain there are many natural fields and almost all around them clay extraction pits, some ofwhich are in the process of deactivation and others being used as fish ponds. This new economic activity in the region has intensified because of one of the projects developed by the Para State Rural Assistance and Extension Company (Emater-Para) as a mitigating measure of the areas altered by clay extraction, making it an economically and socially sustainable alternative. It is noteworthy that this initiative was due to the lack of proper management of natural resource extraction causing a high environmental liability, with the emergence of large abandoned caves, which were filled with surface and groundwater and aquatic vegetation, promoting an unhealthy and dangerous to the health of the population.

It is also worth mentioning that part of these extraction sites are present inside the APP, something relevant because even with the inspection of the environmental agency there are irregular areas making use of this activity, in addition to vegetation suppression and solid waste pollution in several places near the edge of the APP city, causing pollution and silting of the Guamá river (Fig. 10).

Fig. 10: Photographic record of an infrastructure-free stretch of the city's waterfront, with the presence of solid waste, little vegetation and the initial silting process of the Guamá river.

In addition to the use of the floodplain for mining, another activity that has been taking place in the study area, and in the municipality in general, is beef cattle. According to information from the Municipal Finance Department, the activity of the Beef Cattle is in 3rd place, behind the Ceramic Activity and the Logging Activity, respectively, considered one of the most profitable economic activities in the region. Found in 1983 by Embrapa, keeping up to the present day, the development of livestock in the region has led to the formation of indirect services by some farmers and / or cattle breeders, mainly in the axis of Castanhal and São Miguel do Guamá, called pasture rental system (HOMMA et al., 1983).

4.2 Mapping of clay extraction sites and verification of environmental impacts resulting from this activity.

Present in the history of Sao Miguel do Guamá, the ceramic activity is marked by two distinct moments, being the artisanal and industrial phase, this happens because the produced merchandise is still the same: bricks, tiles, but presenting a quite different productivity. Even with the installation of industrial production units in the municipality in the 1980s, only in 1990 was created the ceramic pole, formed by approximately 42 industrialists.In 2009 this set of industries was consolidated as one of the main economic activities of themunicipality, both in the generation of wealth, as well as the generation of jobs, as well as becoming the spatial element of identification of the city, since no city in the northeast has such a marked landscape. by the presence of ceramic industries such as this municipality (CORDOVIL, 2010).

As shown in Fig. 11, there are two substances extracted within the floodplain, clay and sand, the first being the main natural resource extracted from this region, with a total of 51 extraction areas, classified by process phase: search authorization (1), licensing (43) and licensing application (7).

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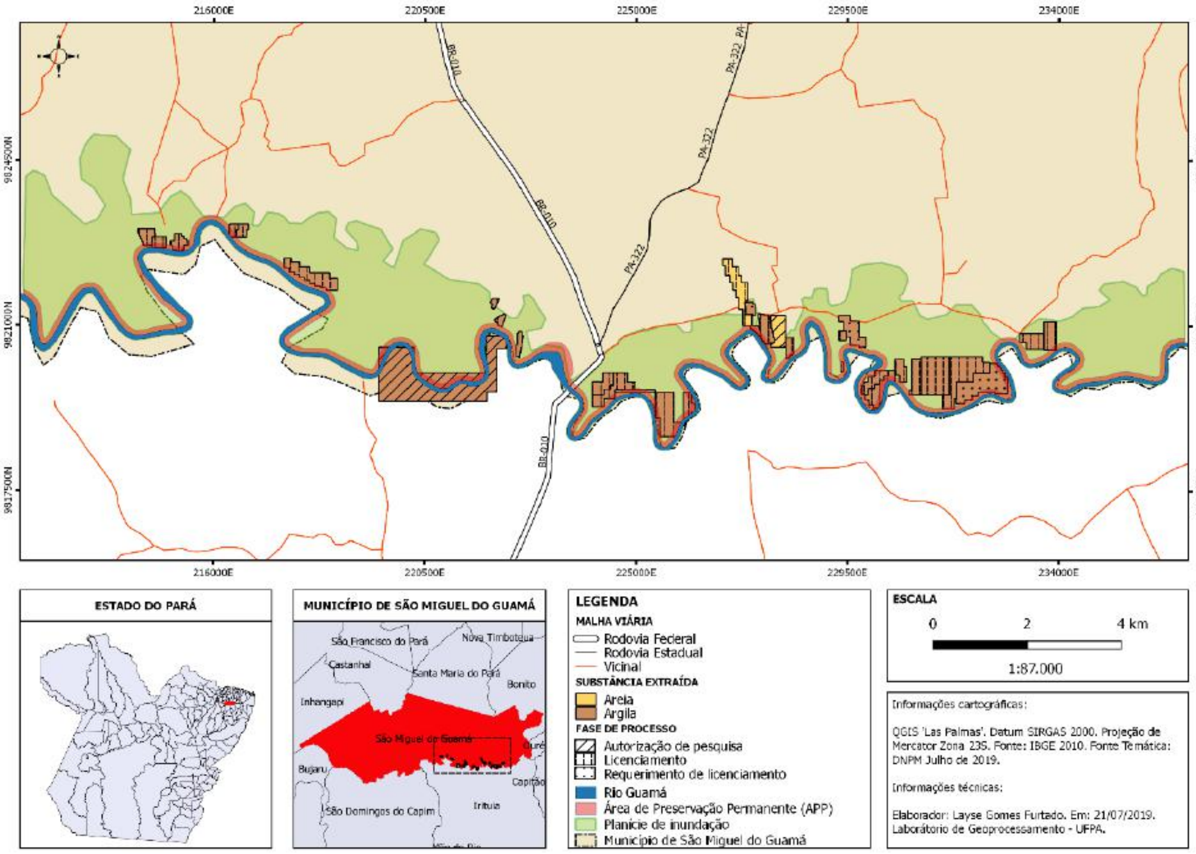

Fig. 11: Mining in the Guamá river floodplain.

With the initial recognition of this area, through laboratory mapping, followed by the field visit, it was possible to identify a pottery (Fig. 12) in activity near the bridge that connects the municipalities of Sao Miguel do Guamá andIrituia, inserted in the plain flood and APP area.

Fig. 12: Photographic register of the pottery.

Almost total vegetation suppression in this area (Fig. 13) and soil compaction were found due to the access of heavy loads on the soil, causing damage to the environment and the population, such as river silting and respiratory problems, since the access road is not paved.

Fig. 13: Photographic record of vegetation suppression in the Guamá river APP near a pottery.

The exploitation and processing of clay have positive impacts on the economy of the municipality, but when extracted irregularly has negative impacts on the environment. According to Para and FIBGE (1995),

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degradation can happen by both human and natural intervention. Human degradation occurs when the natural landscape has been replaced by the artificial landscape. These include degraded areas, such as those undergoing man-made changes, such as those used for livestock, agriculture, trade, industry, buildings, mining and all areas abandoned after use.

The first landscape changes related to the excavation of the mineral extraction process are deforestation and the removal of soils and rocks, which are common effects of open pit mining. As every impact requires a consequence, in mining is no different, due to these changes in the landscape, results such as: elimination of plant and animal species, formation of ponds, loss of stratigraphic record and erosive processes, are environmental consequences of this economic activity.

During the field visit, from a holistic view, it was noticed that in the extraction sites there is presence of the consequences mentioned above, some with higher intensity (vegetation suppression, pond formation and erosion) and others with lower intensity (loss of record). stratigraphic). Regarding the elimination of plant species, it is important to emphasize that deforestation is not restricted to the pits, but extends laterally to facilitate the movement of machinery and equipment, thus affecting the biological cycle in other adjacent areas. This vegetation removal causes the exposure of the soil that is at the mercy of erosive processes, intensely accelerating the amount, shape and arrival rates of rainwater on the ground (SANCHEZ, 1991). In relation to the stagnant waters in the caves, forming lakes, begin to suffer deterioration process, favoring the proliferation of insects and microorganisms harmful to health.

4.3 Environmental assessment of the study area and environmental impact mitigation measures.

From the recognition of the area, the impacts of the ceramic activity and the importance of floodplain conservation it can be inferred that the region has 77.5% of vegetation, whether large or small, used or not for agriculture and livestock, but has an important role in maintaining the ecological balance of the lowland. It was found that there is an intense ceramic activity in this region, covering an area of 10.5% which although smaller than the vegetation classes, is already a significant number in the area given its fragility. Although there is a high amount of vegetation, an evaluation regarding its quality and use has not been performed, and management of these areas for extraction, livestock and even agriculture may occur.

Regarding APP, 18.5% are occupied by this activity, and being a protected area by law, requires greater care, since riparian forest offers several benefits to the environment and quality of life, for example: soil conservation and protection against possible erosion and compaction, barriers to prevent siltation of the Guamá River and its tributaries, and nutrient and water cycling.

According to the data presented on land use and land cover in the floodplain, it appears that there is an environmental balance, even in areas that are occupied by anthropic activities. Attention in these places should be increased, as long as there is profit the tendency to expand the area of activity of activities is inversely proportional to places with vegetation. This reveals to us the importance of the supervision of the competent body and the awareness of the human being with nature.

Given the importance of this ecosystem for life, it is necessary to take actions that aim to minimize adverse events that have the potential to cause environmental impacts to the natural environment, known as mitigation measures. These are present in the Environmental Impact Study (EIA) and the Environmental Impact Report (RIMA) which are required documents for the opening of projects and aims to carry out a comprehensive and complete assessment of significant environmental impacts and indicate the corresponding mitigation measures. This document is necessary to obtain the environmental license, but in some cases, when the undertaking undertaken is not considered patent to cause greater damage to nature, the license can be obtained without the need of EIA / RIMA, as happens in the opening of clay mining in the municipality of Sao Miguel do Guamá.

According to information from the Municipal Secretariat of the Environment, for the opening of the mining in the municipality is required the Operating License (LO) that corresponds to the operation phase of the enterprise, it was emphasized that the Preliminary License and the Installation License are generally united in this single document with the Degraded Areas Recovery Plan (PRAD), which is nothing more than the set of measures that will provide the degraded area with conditions to establish a new dynamic balance, with soil suitable for future use and aesthetically harmonious landscape.

Most PRAD's focus on recovery from native plant species using seedling or no-tillage techniques; transposition of organic soil or litter with propagules and general reforestation. If he does not follow these measures, he must intervene according to the damage and location peculiarities and protect the area from factors that may hinder the area's return to environmental quality, seeking effective results and future performance.

In addition to reforestation in these areas, Para and FIBGE (1995) emphasize that there are various ways of restoration and restoration of areas degraded by mining, such as agricultural use, fish farming, urbanization, recreation areas and landfill.

Below is a presentation of these recovery activities and the appropriate ones suggested by Para and FIBGE (1995), considering the physical-environmental reality of the study area.

Agricultural Use: The implementation of this activity in these areas requires a previous recovery of the organic layer of the soil, which can be done by improving the vegetation cover as well as by replacing the black earth. In the case of tillage, crops should not require large root penetrations, as there is little thickness of the soil horizon, thus restricted to temporary crops (rice, maize, cassava, lettuce, cabbage, etc.).

Fish farming: For this use water can be accumulated naturally as a result of rainfall, or through containment barriers. According to studies presented by Bastos et al. (1998) The introduction of exotic species in these enterprises should be carefully considered, as they risk great losses. Therefore, care should be taken to prevent eggs and fingerlings from escaping from tanks and reaching the Guamá River.

Urbanization: For this alternative, it is recommended to adopt minimum infrastructure in the places where the pits operated and to prepare them to be allocated to families, especially low-income families, or construction of popular houses to be sold to this population, for example. means of long-term financing. Because it is a floodplain, urbanization as an alternative for future use is poorly recognized.

Recreation areas: The use of these exhausted or abandoned areas for leisure should be based on the proximity of the urban center to enable the population's mobility. Again, the nature of the plain limits physical structures, such as football fields and nature parks, etc.

All of these recovery and restoration alternatives mentioned above are some mitigating measures rewritten and restructured according to the necessity and feasibility of the project implementation in the study area. Highlighting, promptly, that the use of fish farming is already being made in most abandoned caves that are located in the flood plain of the Guamá River.

V. CONCLUSION

The present work explored the relationship of the dynamics of land use and land cover in the floodplain, considering its importance for the ecological balance and the well-being of the population of the municipality of Sao Miguel do Guama and surroundings, which benefit through the services of provision offered for the preservation and conservation of their forest.

Based on the results it can be concluded that floodplain forest suppression and fragmentation directly influence the provision of ecosystem services to the local population. The main factor of this loss due to land use change is the activity of clay extraction along the floodplain. This activity makes the municipality of Sao Miguel do Guamá known as the main ceramist district of the north of the country.

Although other types of land use have been identified in this region, mining is still considered as the main anthropic action, causing the most significant environmental impacts, as the extraction of a non-renewable natural resource will bring more damage to the soil than other economicactivities such as extractivism and livestock, existing in the place. However, it is noticeable the presence of competent bodies in the supervision of extraction areas and in the implementation of recovery and restoration projects in areas degraded by mining. One proof of this is the implementation of the fish farming project, which was found during a field visit.

This research is complementary to the identification of possible areas of irregular clay extraction and as a model of evaluation of land use and coverage in the region, as well as to suggest suggestions for the reuse of degraded areas.

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