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Predatory fishing monitoring with the use of geographic information system

Monitoramento de pesca predatória com uso de sistema de informação geográfica

Seguimiento de la pesca depredatoria con el uso del sistema de información geográfica

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Abstract

The Brazilian Institute of Environment and Renewable Natural Resources (IBAMA) determines a regulatory set of instructions for fisheries agreements. These rules control fishing activity in Brazilian basins during closed fishing seasons. However, many fishermen violate the agreements, as seen in the river basin Uba, in the municipality of Moju-Pará. When fishermen breach IBAMA's stated regulations, the municipality is urged to act on the case, but with little knowledge of critical areas which suffer from overfishing. This makes the

logistics of solving these issues difficult and often problematic. This work strives to serve as an aid to environmental agencies in their endeavor to inspect and regulate the issue of overfishing in critical areas, such as the Úba river basin in the municipality of Moju-Para. Our methods include a literature review of research concerning the issue, identifying critical points, as well as preparing maps and proposals for the site of environmental monitoring activities in the city. From within the critical points, we identified the hot spots. We observed five distinct vegetation types located roughly 10 kilometers along the river, and the corresponding agricultural anthropic areas to 49% of the entire study area's territory. It is noted that the areas of greatest concentrations of overfished territories are lined with countryside, forest and dense vegetation. Thus, environmental inspections should take place in areas near the communities and the Úba river and especially in the area beyond the Levi resort, where the hot spot was identified, while always considering the logistics for hard to reach areas.

Keywords: Ubá river; Predatory fishing; GIS.

Resumo

O Instituto Brasileiro do Meio Ambiente e dos Recursos Naturais Renováveis (IBAMA) determina um conjunto regulatório de instruções para acordos de pesca. Essas regras controlam a atividade pesqueira nas bacias brasileiras em épocas de defeso. No entanto, muitos pescadores violam o acordo, como visto na bacia do rio Úba, no município de Moju-Pará. Quando os pescadores violam os regulamentos declarados do IBAMA, o município precisa agir para coibir essas ações, porém há pouco conhecimento das áreas críticas que sofrem com a sobrepesca. Isso torna a logística de resolver esses problemas difícil e muitas vezes pouco eficientes. Este trabalho visa auxiliar os órgãos ambientais em seus esforços de fiscalizar e regulamentar a questão da pesca predatória em áreas críticas, como a bacia do rio Úba, no município de Moju-Pará. Nossos métodos incluíram a revisão da literatura de pesquisas sobre o tema, identificação de pontos críticos, bem como elaboração de mapas e propostas para o local das atividades de monitoramento ambiental na cidade. Identificamos os pontos críticos e observamos cinco tipos de vegetação distintos localizados a cerca de 10 quilômetros ao longo do rio. As áreas antrópicas agrícolas corresponderam a 49% de todo o território da área de estudo. Nota-se que as áreas de maior concentração de territórios sobrepesca são revestidas por áreas de campo, floresta e vegetação densa. Assim, a fiscalização ambiental deve atuar nas áreas próximas às comunidades e ao rio Úba e

principalmente na área além do balneário do Levi, onde foi identificado o hot spot mais significativo, sempre considerando a logística para áreas de difícil acesso.

Palavras-chave: Rio Ubá; Pesca predatória; GIS.

Resumen

El Instituto Brasileño de Medio Ambiente y Recursos Naturales Renovables (IBAMA) determina un conjunto normativo de instrucciones para los acuerdos pesqueros. Estas reglas controlan la actividad pesquera en las cuencas brasileñas durante las temporadas de veda. Sin embargo, muchos pescadores violan el acuerdo, como se observa en la cuenca del río Úba, en el municipio de Moju-Pará. Cuando los pescadores violan la normativa declarada del IBAMA, el municipio debe actuar para frenar estas acciones, pero hay poco conocimiento de las áreas críticas que sufren la sobrepesca. Esto hace que la logística para resolver estos problemas sea difícil y, a menudo, ineficaz. Este trabajo tiene como objetivo ayudar a las agencias ambientales en sus esfuerzos por inspeccionar y regular el tema de la pesca depredadora en áreas críticas, como la cuenca del río Úba, en el municipio de Moju-Pará. Nuestros métodos incluyeron la revisión de la literatura de investigación sobre el tema, la identificación de puntos críticos, así como la elaboración de mapas y propuestas para la ubicación de las actividades de monitoreo ambiental en la ciudad. Identificamos los puntos críticos y observamos cinco tipos diferentes de vegetación ubicados a unos 10 kilómetros a lo largo del río. Las áreas agrícolas antrópicas correspondieron al 49% de todo el territorio del área de estudio. Tenga en cuenta que las áreas con mayor concentración de territorios de sobrepesca están cubiertas por áreas de campo, bosque y vegetación densa. Así, la inspección ambiental debe actuar en las zonas cercanas a las comunidades y al río Úba y principalmente en la zona más allá del balneario de Levi, donde se identificó el hot spot más significativo, considerando siempre la logística para zonas de difícil acceso.

Palabras clave: Río Ubá; Pesca depredadora; GIS.

1. Introduction

Fishing agreements are an important feature in the conservation of fishing activity, as they allow the interruption of fishing during the period of fish reproduction, and guarantee the maintenance of the ichthyofauna for the other months of the year (Flexa, et al., 2018; Oviedo et al., 2015).

To avoid financial consequences of the regulations to fishermen, financial aid from the federal government (known as closed insurance) is provided during this period (Acauan et al., 2018). Even with this compensation, a portion of the fishing professionals do not comply with the agreement and maintain fishing activity during the closed season.

In addition, it is common to use resources considered unsuitable and/or damaging for fishing, due to the environmental impact they cause, both in the closed season and during the rest of the year (Tavares & Dias, 2014). Such methods of fishing are cited in environmental crime law and include the use of fishing poisons or explosives.

The municipality of Moju has established a fishing agreement for the Ubá and Jambuaçu river basins, in accordance with Normative Instruction No. 22 of March 30, 2004, which authorizes fishing prohibition and permissions in the period from November 1 to February 28th (IBAMA, 2004). During this period, the prohibitive actions instituted by the fisheries agreement are constant, mainly on the Ubá River. The Moju municipality's environment department receives numerous complaints about predatory fishing during the closed season. The municipality is responsible in varying capacities for supervising and interrupting this activity, as well as reprimanding offenders.

Based on the problematic nature of the situation, this work seeks to discuss the critical points of predatory fishing in the Ubá River. We accomplish this through on the spot verification and the design of various maps. This allows us to visualize the areas featuring the greatest concentration of illegal fishing activities, marking the basin as a site and object of environmental study to which decision making processes are able to refer. This information might prove helpful in environmental supervisory bodies' endeavor to take appropriate actions to comply with the Ubá River fishing agreement.

2. Methods

2.1 Area of study

Moju, belonging to the homogeneous microregion of Tomé-Açu, is located in the ecological-economic zone, ZEE Moju-Capim (Silva et al., 2001). The Moju river's main stretch is situated within the town of Moju. The river is the largest in extension and in the drainage area, with 800 km and 15,658 km², respectively--with the source located in the municipality of Rondon do Pará, crossing the municipalities of Goianésia, Breu Branco and Moju. It borders the municipalities of Moju and Abaetetuba, and the main tributary is the

Camarí River. The Ubá River is the largest tributary of the Moju River in the municipality's vicinity.

Moju's landscape features soils of a yellow latosols class, quartzous sands and alluvial soils, present by the dense vegetation of plain alluvials, and corresponding to the areas close to the rivers that cross the municipality. Also present is the secondary latifoliate vegetation of dryland forest and the dense forest of the low plateaus and terraces, with a moderate topographic variation in the region. It has altimetric levels close to 30 meters and the location of the municipality at 18 meters from sea level (IDESP, 2012).

The Ubá hydrographic basin belongs to a hydrographic group that makes up the Atlantic Coast-Northeast Sub-region of Guamá-Mojú. This area is considered to be the most densely populated region in the state of Pará. Therefore, the management of water usage which fisheries regulate, is crucial.

The Ubá River has a long extension, bathing much of Moju. Its watershed is of paramount importance for rural communities, offering agricultural subsidies, fishing, among other benefits. Much of the hydrographic basin is also occupied by logging and oil palm plantations. The Ubá river is used for tourism purposes, being frequented by jet ski groups and swimmers in the public Levi resort.

2.2 Obtaining predatory fishing data

Exploratory and descriptive research was carried out on illegal fishing spots. Qualitative and quantitative analyses were applied in relation to the collected data, using the observation technique (Pereira et al., 2018).

The surveys of predatory fishing spots on the Ubá River were carried out on the 9th and 18th of November 2015, and consisted of obtaining information provided by the participants of the Ubá River fishermen's cooperative. GPS model Garmin Montana 650 was used to mark the geographical coordinates. Our fieldwork methods allowed consolidation of various methodological steps during the geoprocessing analysis in the laboratory. We had the support of the Secretariat of Science, Technology, and Environment of Moju (SECTEMA), the 29th group of the fire brigade of the municipality of Moju, and the Military police. They guided us as we reached the locations where illegal fishing took place.

2.3 Mapping of predatory fishing concentration

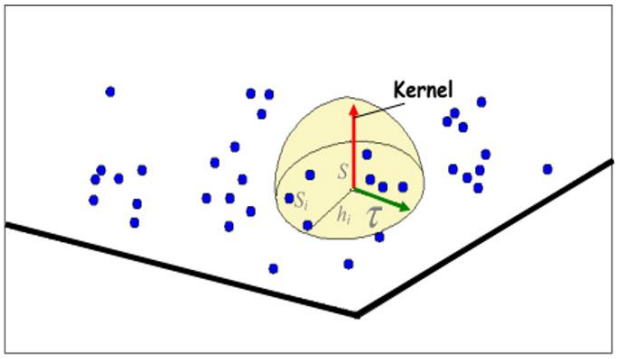
In mapping the concentration of predatory fishing points, the Geographic Information Systems - GIS were used, described as systems that generate complex analyses by integrating data from different sources and creating georeferenced databases (Matsumoto & Flores, 2012).

GISs consist of information systems aimed at manipulating and processing geographic data from objects and phenomena with inherent spatial characteristics (Câmara et al., 1996; Gonçalves et al., 2016). These systems contain data from precise surveys of the Earth's surface geo-referenced, which links the database to a cartographic projection, making it possible to mark an object and know the value of its attributes, or by selecting a record from the database and knowing its location, showing it visually in the respective software.

In a GIS, there are geoprocessing tools such as the Kernel intensity estimator that refers to a smoothing density estimation method and basically serves to identify “hot spots” (Câmara et al, 2004). The Kernel intensity estimator is useful when there is a dense concentration of points, resulting in an overview of the intensity of the phenomena in focus.

Rocha et al. (2011) showed that in order to estimate the intensity of a phenomenon, all points within a region of influence are counted, weighing them by the distance of each one to the location of interest. Figure 01 shows this process:

Figure 1. Intensity estimator for a dot pattern.



Source: Rocha et al., (2011).

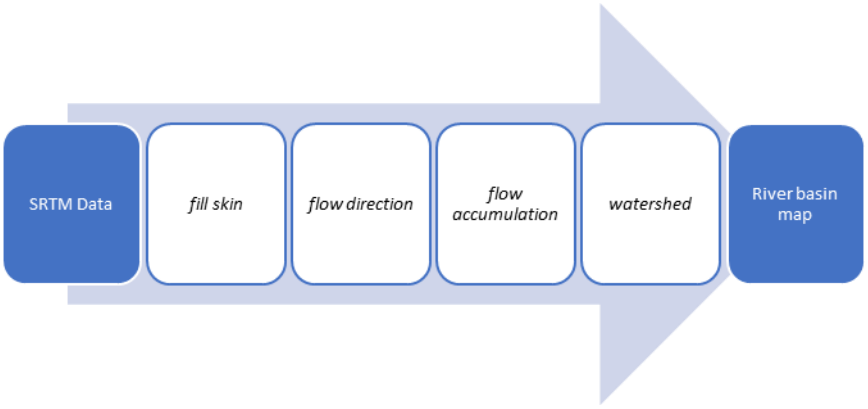
Thus, the kernel function interpolates an intensity value for each cell in a grid, considering a symmetrical function, used for the calculation of points located within a certain distance from the center of the cell (Matsumoto & Flores, 2012).

2.4 Delimitation of the Ubá River basin

To determine hydrographic basin and drainage network of the Ubá River, we used the computational package ArcGis 10.1, according to the methodology proposed by Alves Sobrinho et al. (2010) subdivided into four stages: fill skin, flow direction, flow accumulation and watershed, as seen in Figure 2.

In this phase, we used primary data produced from the Digital Elevation Model (MDE) extracted from SRTM images (Shuttle Radar Topography Mission) and we associated with the USGS images (US Geological Survey) administered by NASA (National Aeronautics and Space Administration), with spatial resolution 90 meters and SIRGAS 2000 reference ellipsoid.

Figure 2. Flowchart of the steps for the delimitation of watersheds by means of SRTM images.



Source: Authors, (2020).

The first step for the manipulation of SRTM data consists of filling in the flaws caused by areas surrounded by elevations with higher dimensions, causing a form of depression, which is adjusted based on the execution of the algorithm promoting better quality to the model.

The flow direction stage involves generating a regular grid, defined from the Euclidean distance, where the water flow of each pixel is defined from the direction of its 8 neighboring pixels. Then the accumulated flow or degree of confluence of the flow is generated and can be called the catchment area (Alves Sobrinho et al., 2010). The data processing algorithm between the flow direction and the accumulated flow is responsible for generating the delimitation factor of the hydrographic basins.

The hydrographic network was generated from the accumulated flow of water compared to the geographic coordinates collected “in loco.” Finally, the EAW was used to create slope and altimetry maps that were reclassified, assigning the Datum reference SIRBAS 2000.

2.5 Environmental characterization

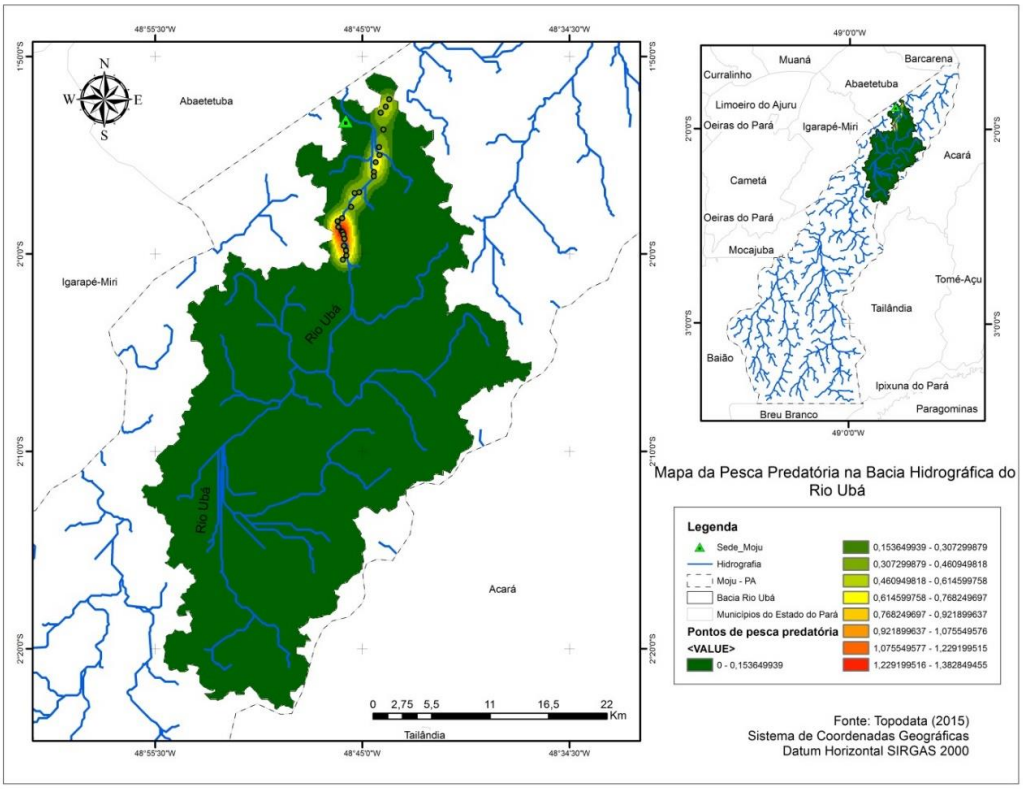
After the research and data collection phase, the digital files referring to the cartography of the study area and predatory fishing spots were systematized, stored and organized in specific directories through a GIS.

Thematic bases of land use, altimetry, and slope were crossed, obtained from the database of the Geological Map of the State of Pará (Vasquez et al., 2008).

3. Results and Discussion

We traveled 17 kilometers along the Ubá River, starting from the municipal headquarters, where 23 predatory fishing spots were identified, as shown in Figure 3.

Figure 3. Critical points of predatory fishing on the Ubá River.



Source: Authors, (2020).

From the critical points identified, active regions, “hot spots” were observed about 14 kilometers from the municipal urban area along the river, as seen in figure 3, this fact can be explained by ongoing deforestation and anthropogenic impacts that cause imbalance and the consequent migration of aquatic species to more distant habitats. Fish assemblages are susceptible to species loss and reduced biodiversity due to changes induced in areas in close proximity to urban life (Cunico et al., 2006).

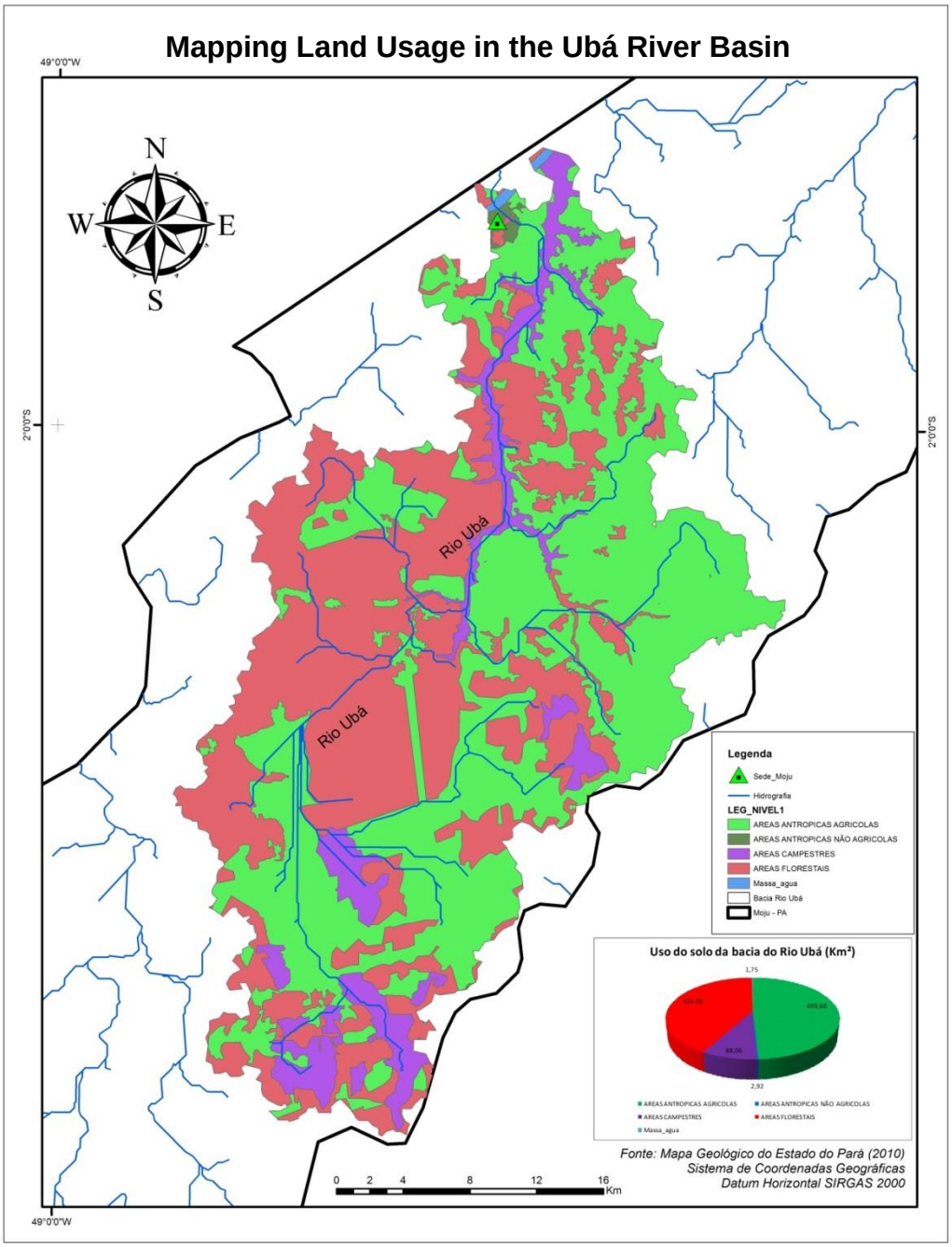
The Ubá river basin faces some environmental problems, most of which are man-made. Miranda (2016) lists the main changes that occur in the Ubá river basin: a) cutting and burning the riparian forest; b) deposition of garbage and domestic sewage in rivers; c) health problems (mycoses and diarrhea) related to poor water quality in rivers; d) disorderly logging in riparian forest; e) clearing of riparian forest; f) use of pesticides in agricultural crops, grown on the banks of this river and its tributaries; g) silting up of the Ubá River and its tributaries; h) disappearance of sources.

In the Ubá River, the occupation process combined with selective logging, agricultural activity and livestock have caused drastic changes in the areas of primary and secondary forests, compromising riparian forests, springs and water quality. The most intense impacts to be observed are deforestation and forest fragmentation in the areas of springs and riparian forests of the tributaries of the Ubá River (Miranda et al., 2017).

Among the aforementioned activities that compromise water quality, agricultural activity, the production and handling of palm oil stands out. This economic activity is the one that most contributes to the rapid changes of terrestrial, aquatic habitats and the diversity of plant and animal species (Luskin & Potts, 2011).

When analyzing the map of land usage and occupation of the Ubá river basin (see Figure 4) five distinct vegetation classes were identified, with the agricultural anthropic areas comprising 49% (in green) of the entire territory of the study area. Along relevant river sections, the rural areas border the entire length of the strand.

Figure 4. Map of land usage in the Ubá river basin.



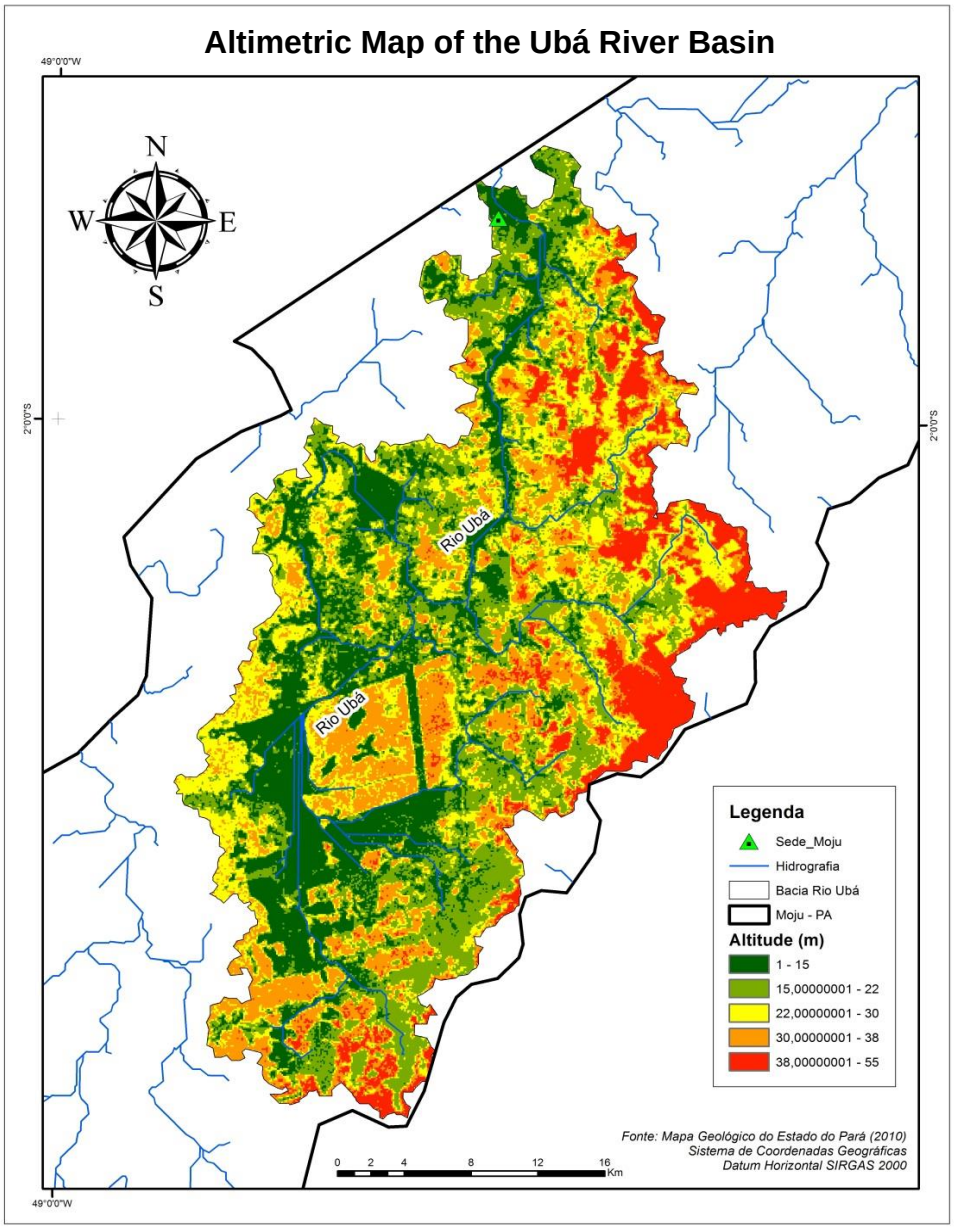
Source: Authors, (2020).

Comparing the use and occupation of the land with the map of predatory fishing points, it is clear that the areas with the highest concentrations of predatory fishing are bordered by rural areas overlapping with forest areas, and composed of dense vegetation. This makes the efforts put forth by environmental organizations to oversee and interrupt suspicious practices an ambitious task.

The altimetric analysis of the Ubá river basin varies between 1 - 22 meters over the entire water resource, with a variation of between 1 - 15 meters, for the areas highlighted as having the highest concentration of predatory fishing in the basin.

Thus, topographic variations existing in the municipality are seen, with its headquarters located on the banks of the Moju River, with floodplains, which cut a part of the city where there are stilts. The location of the municipal headquarters, in the lowest area, may have an influence on the movement of effluent discharge into the Moju River since the topography helps in the flow to the river.

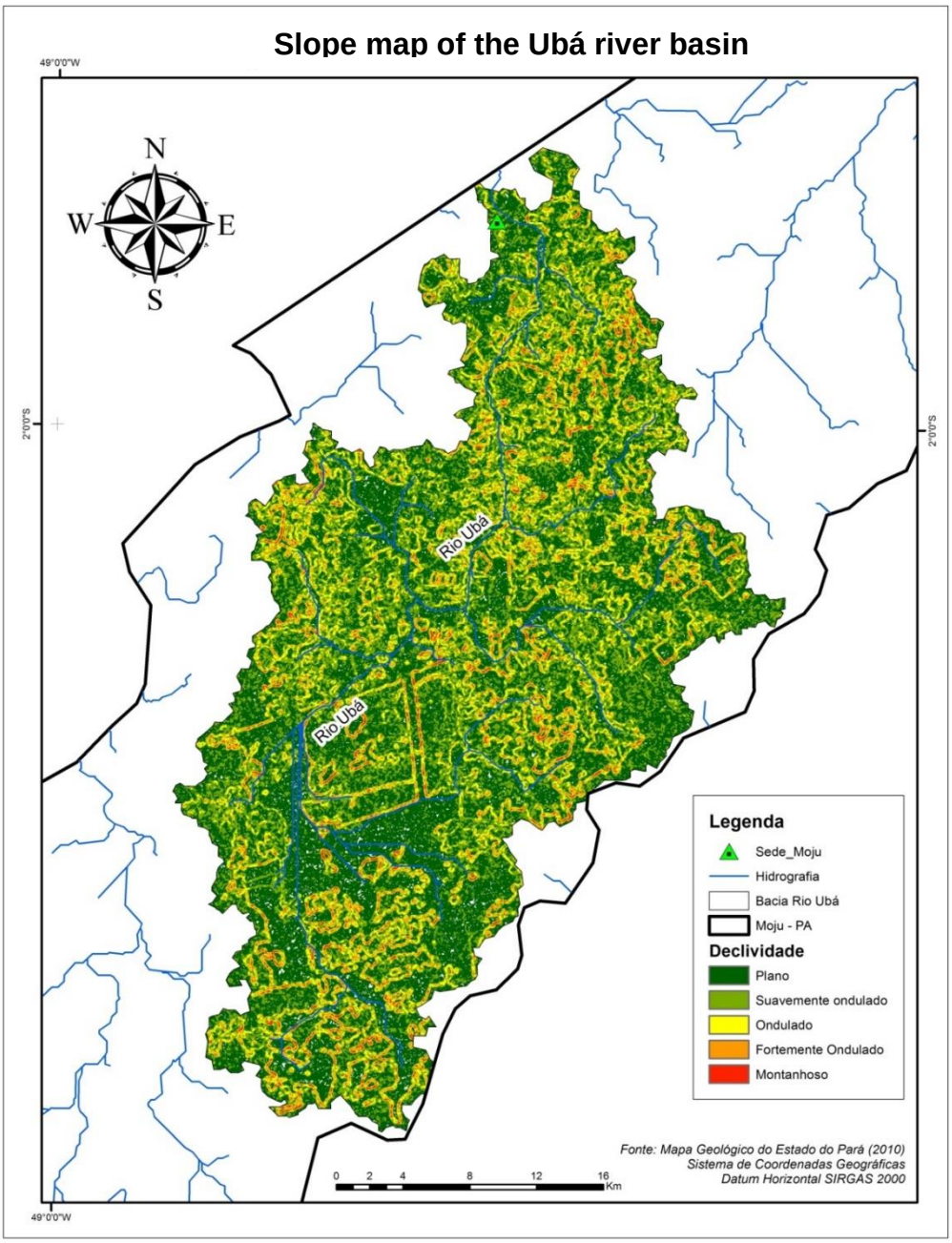
Figure 5. Altimetric Map of the Ubá River Basin.



Source: Authors, (2020).

As the centerpiece of this study, the basin can be observed in terms of its slope; it varies from flat to wavy, with the hot spots generated from predatory fishing points determined predominantly in wavy areas.

Figure 6. Slope map of the Ubá river basin.



Source: Authors, (2020).

In terms of logistics, the maps generated in this study were observed to the conclusion that the concentrations of critical points are 17 km in length along the Ubá River, making inspection and action difficult mainly in places containing larger closed forests.

However, the biggest hot spot is a place that is relatively accessible to fishermen, both to riverside residents and to others who come from the municipal headquarters. These logistics must also be overseen by SECTEMA. To reach the hot spot, the point of access we recommend is via the resort of Levi, whose road is fully paved. Enter the Ubá River through the same resort, which does not have riparian forest in a small extension. Thus, the community of Ateuazinho, Limoeiro becomes more accessible for observation, even at night.

Other locations considered critical were observed throughout the riverside communities. These are the most difficult to access when leaving the municipal headquarters, as they have unpaved branches as the main entrance. However, none of these branches are located far from the municipal headquarters, and through the bridges that integrate these areas, the entrance to the Ubá river can be made. There is then the possibility of arriving at the critical points of the Congregation, Santa Bárbara and Pensão Era communities, as well as in the other points perceived along this extension, which include the entrance to streams (tributaries of the Ubá river) and agglomerates and residences, through the extension of the Congregation.

The same directions can be followed to reach the other points. Through the Jambuaçu Branch, it is possible to enter the Ubá River through the Jambuaçu Bridge and arrive at the critical points of the Jambuaçu, Santa Maria and Conceição communities, as well as in the other critical points observed, which include conglomerates of homes and boreholes.

4. Conclusion

The map of the Ubá River Basin afforded the study a more comprehensive view of the dimensions of the target basin as well as its characterization from the maps of land use, altimetry and slope. For land use, 49% of the basin's area is characterized as agricultural anthropic areas, with an altimetry of 1 - 55 meters and predominantly flat slope. However, the vicinity of the Ubá River is characterized as undulating.

With the elaboration of the kernel maps for the identification of the areas with the highest concentration of predatory fishing, it can be concluded that they are more distant from the municipal headquarters, caused mainly by the migration of fish which often happens next to areas which suffer from anthropic intervention.

In this sense, a better characterization of the Ubá River basin and intensified inspection are recommended. In order for the offenders to be reached, it is necessary that there is urgent and thorough action from the environmental inspection body and reliable mapping

of the most critical points of predatory fishing in the Ubá River, taking into account the great length of the river. The present study may provide subsidies in the decision making process involved in various facets which concern the issue of predatory fishing in the Ubá River. For future work, we recommend the temporal monitoring of predatory fishing points and the expansion of the study area.

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