MORPHOMETRIC CHARACTERISTICS OF THE MELISSA RIVER MICRO-WATERSHED AND ESTIMATION OF NITROGEN ANS PHOSPHORUS INPUTS FROM FISH FARMNING PONDS

CARACTERÍSTICAS MORFOMÉTRICAS DA MICROBACIA HIDROGRÁFICA DO RIO MELISSA E ESTIMATIVA DO APORTE DE NITROGÊNIO E FÓSFORO ORIUNDOS DE VIVEIROS ESCAVADOS E PISCICULTURA

CARACTERÍSTICAS MORFOMÉTRICAS DE LA CUENCA DEL RÍO MELISSA Y ESTIMACIÓN DEL APORTE DE NITRÓGENO Y FÓSFORO DE ESTANQUES DE PISCICULTURA EXCAVADOS

https://doi.org/10.56238/sevened2025.029-071

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ABSTRACT
Advances in geotechnology have increased the accuracy of environmental monitoring, making remote sensing essential for watershed management. This study analyzed the Melissa River microbasin, a tributary of the Piquiri River (western Paraná), to characterize morphometric aspects, map excavated ponds, and estimate nutrient input from fish farming. The basin was delimited using Digital Elevation Model (30 m) images processed in QGIS 3.22.14 and GRASS GIS, generating maps of slope, hypsometry, soils, and land use. The morphometric analysis included eight indices, and the pond mapping used Google Earth® imagery. The microbasin has flat to gently undulating relief, with altitudes ranging from 220 to 820 m, with a predominance of 520–720 m (72.26%). The soils are predominantly RED LATOSOL (75%), followed by RED NITOSOL (19.46%), suitable for fish farming due to their impermeability. Land use is dominated by soybeans (63.65%), followed by forests (15.65%). The indices (Kc=2.73; Dd=0.89) indicate an elongated shape, low runoff, and low flood risk. A total of 278 ponds were identified, 70.86% of which were class I, but class III ponds accounted for 52.60% of the water table. The estimated production was 4,373 t, with 199.66 t of nutrients contributed by breeding and 8.51 t by harvesting. It is concluded that the microbasin presents favorable conditions for aquaculture, but larger ponds require management to reduce eutrophication, highlighting the importance of geotechnologies in water management.

Keywords: Aquaculture. Geotechnologies. Geoprocessing. Hydrology.

RESUMO
O avanço das geotecnologias tem aumentado a precisão no monitoramento ambiental, sendo o sensoriamento remoto fundamental para a gestão de bacias hidrográficas. Este

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estudo analisou a microbacia do rio Melissa, afluente do rio Piquiri (oeste do Paraná), visando caracterizar aspectos morfométricos, mapear viveiros escavados e estimar o aporte de nutrientes da piscicultura. A delimitação da bacia foi realizada a partir de imagens do Modelo Digital de Elevação (30 m) processadas no QGIS 3.22.14 e GRASS GIS, gerando mapas de declividade, hipsometria, solos e uso do solo. A análise morfométrica contemplou oito índices, e o mapeamento dos viveiros utilizou imagens do Google Earth®. A microbacia apresenta relevo plano a suavemente ondulado, com altitudes entre 220 e 820 m, predominando 520–720 m (72,26%). Os solos são majoritariamente LATOSSOLO VERMELHO (75%), seguidos de NITOSSOLO VERMELHO (19,46%), adequados à piscicultura pela impermeabilidade. O uso do solo é dominado por soja (63,65%), seguido por florestas (15,65%). Os índices (Kc=2,73; Dd=0,89) indicam forma alongada, baixo escoamento superficial e baixo risco de enchentes. Foram identificados 278 viveiros, 70,86% de classe I, mas viveiros de classe III concentraram 52,60% da lâmina d'água. A produção estimada foi de 4.373 t, com aporte de 199,66 t de nutrientes na criação e 8,51 t na despesca. Conclui-se que a microbacia apresenta condições favoráveis à aquicultura, mas viveiros maiores demandam manejo para reduzir eutrofização, destacando a importância das geotecnologias na gestão hídrica.

Palavras-chave: Aquicultura. Geotecnologias. Geoprocesamento. Hidrologia.

RESUMEN

Los avances en geotecnología han incrementado la precisión del monitoreo ambiental, haciendo que la teledetección sea esencial para la gestión de cuencas hidrográficas. Este estudio analizó la microcuenca del río Melissa, un afluente del río Piquiri (oeste del Paraná), para caracterizar aspectos morfométricos, mapear estanques excavados y estimar el aporte de nutrientes de la piscicultura. La cuenca se delimitó utilizando imágenes del Modelo Digital de Elevación (30 m) procesadas en QGIS 3.22.14 y GRASS GIS, generando mapas de pendiente, hipsometría, suelos y uso del suelo. El análisis morfométrico incluyó ocho índices, y el mapeo de los estanques utilizó imágenes de Google Earth®. La microcuenca tiene un relieve plano a suavemente ondulado, con altitudes que varían de 220 a 820 m, con un predominio de 520 a 720 m (72,26%). Los suelos son predominantemente LATOSOL ROJO (75%), seguido de NITOSOL ROJO (19,46%), adecuados para la piscicultura debido a su impermeabilidad. El uso del suelo está dominado por la soja (63,65%), seguido de los bosques (15,65%). Los índices (Kc=2,73; Dd=0,89) indican una forma alargada, baja escorrentía y bajo riesgo de inundación. Se identificaron 278 estanques, de los cuales el 70,86% fueron de clase I, pero los estanques de clase III representaron el 52,60% del nivel freático. La producción estimada fue de 4.373 t, con 199,66 t de nutrientes aportados por la crianza y 8,51 t por la cosecha. Se concluye que la microcuenca presenta condiciones favorables para la acuicultura, pero los estanques de mayor tamaño requieren manejo para reducir la eutrofización, lo que resalta la importancia de las geotecnologías en la gestión del agua.

Palabras clave: Acuicultura. Geotecnologías. Geoprocesamiento. Hidrología.

1 INTRODUCTION

The growing need to find a balance between human development and environmental protection has gained relevance, especially in relation to the deterioration of water quality in rivers and lakes. This is due to the pressure exerted by human activities on water sources, although there is also the influence of natural factors. The scarcity and pollution of water resources negatively impact public health, food security, biodiversity, and socioeconomic progress, making it essential to implement strategies that promote their conservation and sustainable use.

With the advancement of technologies, remote sensing tools are becoming increasingly accurate and effective, making it easier to detect patterns in the landscape. An example is the Multiscale Ottocoded Hydrographic Base – Version 6, prepared by the National Water and Basic Sanitation Agency (AMORIM et al., 2015), which developed a geospatial tool capable of accurately identifying the movement of water in watersheds.

The application of geotechnologies allows the production of data and information through detailed spatial analysis, expanding access to relevant data for a variety of users and purposes (CRISCUOLO, 2016; CORRÊIA, 2023). This monitoring capacity is essential for a more effective and sustainable management of water resources. In addition, the morphometric characterization of drainage basins, which involves the detailed analysis of physical parameters, is crucial to describe their structural and functional characteristics. These data are indispensable for predicting hydrological phenomena, such as floods and floods, allowing better preparation and response to such events (MIOTO, 2014).

In view of this scenario, the implementation of Law No. 9,433, in January 1997, gave rise to the National Water Resources Plan (BRASIL, 1997), aimed at facing the challenges associated with the conservation and management of these waters, especially in the midst of climate change. The law establishes that, in periods of water scarcity or when there is a risk of environmental compromise, the government may suspend or restrict grants already granted, in order to ensure the priority use of water. Although conflicts related to the use of water resources are a relatively recent phenomenon, they have worsened in recent decades as a result of the expansion of irrigation areas, the growth of fish farming, and rapid urbanization in several regions of Brazil (SOUZA et al., 2020).

Aquaculture causes environmental changes, but its impacts can be minimized with the rational use of resources. The adoption of sustainable practices, based on appropriate legislation and guidelines, contributes to preventing irreversible damage (SIPAÚBA-

TAVARES, 2013). For this, it is essential to understand the factors that influence eutrophication in watersheds, ensuring responsible management.

The integration between the use of geotechnologies and the sustainable management of aquaculture becomes even more relevant in the face of the growing demand for aquaculture foods. In this context, studies that combine geoenvironmental and hydrological analyses provide fundamental subsidies for public policies aimed at territorial planning, allowing production and conservation to be compatible. The spatial analysis of the watersheds also makes it possible to understand how the arrangement of the excavated ponds influences the nutrient cycle and the dynamics of the landscape. In addition, the results obtained can contribute to impact mitigation strategies, such as the adoption of buffer zones and appropriate management techniques. In this way, research assumes a strategic role, as it aligns environmental planning tools with responsible production practices, strengthening aquaculture as an essential activity for economic development, but in accordance with the conservation of water resources and associated ecosystems.

The objective of this study is to perform a morphometric analysis of the Melissa River watershed, map the excavated ponds of the aquaculture production units and estimate the contribution of the nutrients nitrogen and phosphorus, in order to understand their impacts on water quality and hydrological processes in the region, through geospatial analysis.

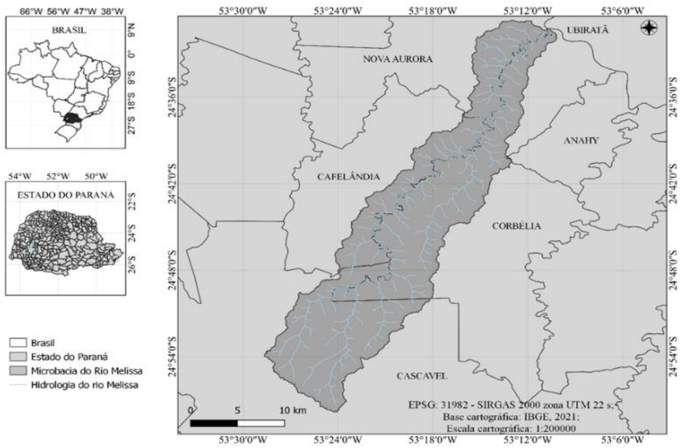
2 METHODOLOGY

2.1 PLACE OF STUDY

The Melissa River watershed is a direct tributary of the left bank of the Piquiri River, whose sources occur in the urbanized area of the municipality of Cascavel, extending through the municipalities of Corbélia, Cafelândia, Nova Aurora, Ubiratã and Anahy (IBGE, 2024), as illustrated in Figure 1. The watershed has an equatorial tropical climate, with an average annual rainfall of approximately 1,600 mm, and is classified as a humid subtropical climate (Cfa), according to the Köppen classification (KÖPPEN, 1936).

Figure 1

Location of the Melissa River watershed, inserted in the Piquiri River watershed, western region of the state of Paraná, Brazil



Source: Prepared by the authors, 2025.

2.2 DELIMITATION OF THE MELISSA RIVER WATERSHED

The delimitation of the watershed was carried out using the Digital Elevation Model (MDE), with a spatial resolution of 30 meters, whose images were obtained from the United *States Geological Survey* (USGS, 2021) portal. The process began with the application of the *r.fill.dir* algorithm, which corrects possible pixel continuity errors. From the capture of the coordinates of the main river outlet, both the watershed and the drainage network were delimited in the *Geographic Resources Analysis Support System* (*GRASS GIS*) software, using the algorithms *r.waterhed*, responsible for the delimitation of the basin, and *r.water.outlet*, used for the delimitation of the hydrography of the watershed. Then, both rasters were converted to vector format with the *r.to.vect algorithm (MORSOLETO et al., 2023). All algorithms employed during the delimitation of the watershed and its hydrography are native to the QGIS Development Team* software (2021).

2.3 PHYSICAL ANALYSIS OF THE MELISSA RIVER WATERSHED

The characterization of the Melissa River watershed was carried out based on four main aspects: slope and hypsometry, soil types and land use and occupation. The slope and hypsometry maps were generated from the Digital Elevation Model (MDE), using the *QGIS* 3.22.14 software, with the support of the GRASS GIS *r.report algorithm*, following the methodologies of Macedo et al. (2023) and Werneck et al. (2023).

The analysis of soil types was based on vector data from EMBRAPA, at a scale of 1:250,000, according to the methodologies of Francisco et al. (2019) and Morsoleto et al. (2023), with the calculations carried out using the *QGIS attribute calculator*.

The data on land use and occupation were obtained from the *MapBiomas project portal*, in raster format, with a scale of 1:100,000 and a spatial resolution of 30 meters, and the calculations were also performed with the r.report algorithm, native to *GRASS GIS* within *QGIS*.

2.4 MORPHOLOGY AND MORPHOMETRY OF THE MELISSA RIVER WATERSHED

The analysis of the physiographic characteristics of the Melissa River watershed is a fundamental step to understand its hydrological and environmental dynamics. These parameters allow the identification of specific physical indicators that help in the evaluation of possible changes in the environment. From a quantitative point of view, the application of morphometric analysis stands out, which involves the determination of indices such as drainage density, compactness coefficient, circularity index and basin shape, among others. As pointed out by Georgin et al. (2015), this procedure consists of surveying numerical values of different attributes of the basin, making it possible to interpret the functioning of its drainage system and subsidizing studies aimed at environmental management and planning.

With the geometric parameters provided by the remote sensing geotechnologies, the data were geoprocessed in the field calculator, in order to analyze the eight morphometric indices, according to the formulas contained in Table 1. The calculations were performed using *the QGIS* software, version 3.22.14 (QGIS Development Team, 2021).

This approach allows relating the physical characteristics of the basin with hydrological processes and potential environmental impacts, providing important subsidies for decision-making in the management of water resources.

Table 1

Calculations of the morphometric indices performed for the Melissa River watershed, Piquiri River watershed, western region of the state of Paraná, Brazil

Index	Formula	Description of items
Kc – Compactness coefficient	$\mathrm{Kc} = 0{,}28 * \left(\frac{\mathrm{P}}{\sqrt{\mathrm{A}}}\right)$	P: Perimeter of the basin (m); A: Basin area (m²)
F – Form Factor	$\mathrm{F} = \frac{\mathrm{A}}{\mathrm{E}^2}$	A: Basin area (m²); E: Basin Shaft Length (m)
Ic - Circularity Index	$\mathrm{Ic} = \frac{12{,}57 * \mathrm{A}}{\mathrm{p}^2}$	A: Basin area (m²); P: Basin Perimeter (m)
Dd - Drainage Density	$\mathrm{Dd} = \frac{\mathrm{Lt}}{\mathrm{A}/1000}$	Lt: Length of drainage network (km); A: Basin area (km²)
Tc - Concentration time	$\mathrm{Tc} = 57 * \left(\frac{\mathrm{L}/1000^3}{\mathrm{H}}\right)^{0{,}385}$	L: Length of the main thalweg (km); H: Difference in level between the highest part and the control section (m)

Is - Sinuosity Index	$Is = \frac{100 \times (L - Lr)}{L}$	L: Length of main river (m); Lr: Talweg length of main river (m)
Er - Elongation ratio	$Er = 1{,}128 \times \frac{\sqrt{A}}{E}$	A: Basin area (m²); E: Length of bowl shaft (m)
Rr - Relative relief	$Rv = \frac{H}{P}$	P: Perimeter of the basin (m); H: Altimetric range (m)

Source: Adapted from Georgin et al. (2015).

2.5 MAPPING OF EXCAVATED NURSERIES AND HIGHWAYS OF THE MELISSA RIVER WATERSHED, PIQUIRI RIVER BASIN, IN THE WEST OF THE STATE OF PARANÁ, BRAZIL

The location, mapping, and quantification of the nurseries excavated in the Melissa River watershed region were carried out using *Google Earth*® and *the QGIS software*, version 3.22.14 (QGIS Development Team, 2021), according to Werneck et al. (2023). The nurseries were classified into three categories:

- Class I - small nurseries: with an area between 300m² and 3,000m²;
- Class II - medium-sized nurseries: with areas between 3,001m² and 6,000m²;
- Class III - large nurseries: with an area greater than 6,001 m².

To be considered excavated ponds intended for fish farming, the satellite images of the ponds must present typical characteristics of aquaculture enterprises, such as the presence of ponds with an area greater than 300 m², access roads for the flow of production and sheds or other constructions associated with aquaculture activity.

The road map was prepared according to the methodology of Luiz Junior et al. (2024). The road vectors, at a scale of 1:250,000, were obtained from the portal of the Brazilian Institute of Geography and Statistics (*IBGE*, 2021), and the delimitation of the watershed was used to cut the roads located within its area.

2.6 NUTRIENT INTAKE IN THE MELISSA RIVER WATERSHED, PIQUIRI RIVER WATERSHED, WESTERN REGION OF THE STATE OF PARANÁ, BRAZIL

The estimated calculations of residual nutrient discharge in the Melissa River watershed, from fish farming in excavated ponds, were carried out based on the study by Coldebella et al. (2020). For this estimate, the cultivation area and the average biomass produced from 5 kg/m² of water surface were considered, corresponding to the excavated ponds mapped and classified in this work. The reference values are indicated in Table 2, adapted from Macedo et al. (2024).

Table 2

Estimated values of total nitrogen and total phosphorus input by class of excavated ponds, during the nine-month cultivation and harvesting, considering an average stocking density of 5 kg/m²

Classes	Size (m²)	Reference values			
		Creation		Fishing	
		Nitrogen (kg/ha)	Phosphorus (kg/ha)	Nitrogen (kg/ha)	Phosphorus (kg/ha)
I	300 - 3000	2.047,70	261,91	54,59	16,47
II	3.001 – 6.000	1.951,05	197,30	120,49	26,11
III	> 6,000	2.055,85	260,99	81,56	12,18

Source: Adapted from Coldebella et al. (2020).

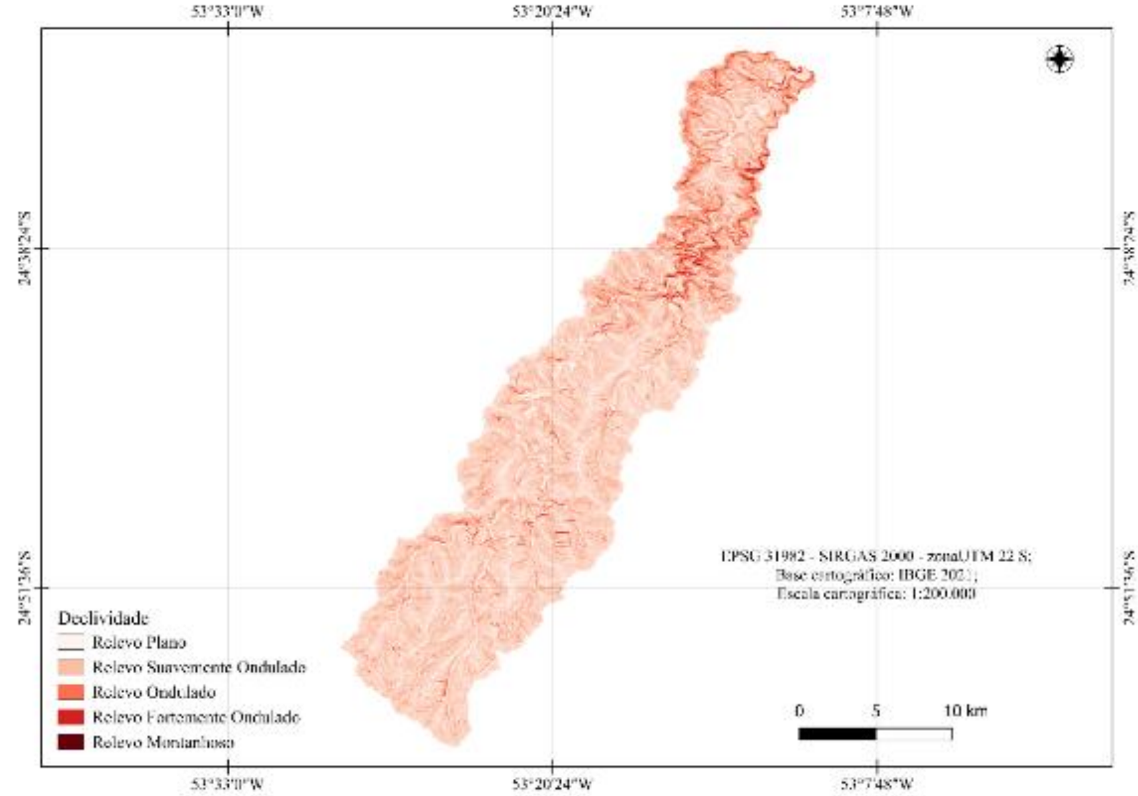
3 RESULTS AND DISCUSSIONS

In the Melissa River watershed, most of it has a flat relief, while a smaller portion has a gently undulating relief (Figure 2), similar to that observed in the Chororó River watershed, studied by Macedo et al. (2023). These types of relief are considered favorable for the implementation of new fish farms in excavated ponds, because the lower the undulation of the land, the more viable the installation of the activity becomes, due to less soil movement, which reduces the costs of machinery and equipment (Francisco et al., 2019).

In addition, the homogeneity of the relief facilitates the construction of efficient drainage systems, contributing to the maintenance of water quality in nurseries. These physical conditions allow for strategic planning of the distribution of nurseries, minimizing environmental impacts and promoting greater productivity of aquaculture activity.

Figure 2

Slope of the Melissa River watershed, Piquiri River watershed, western region of the state of Paraná, Brazil



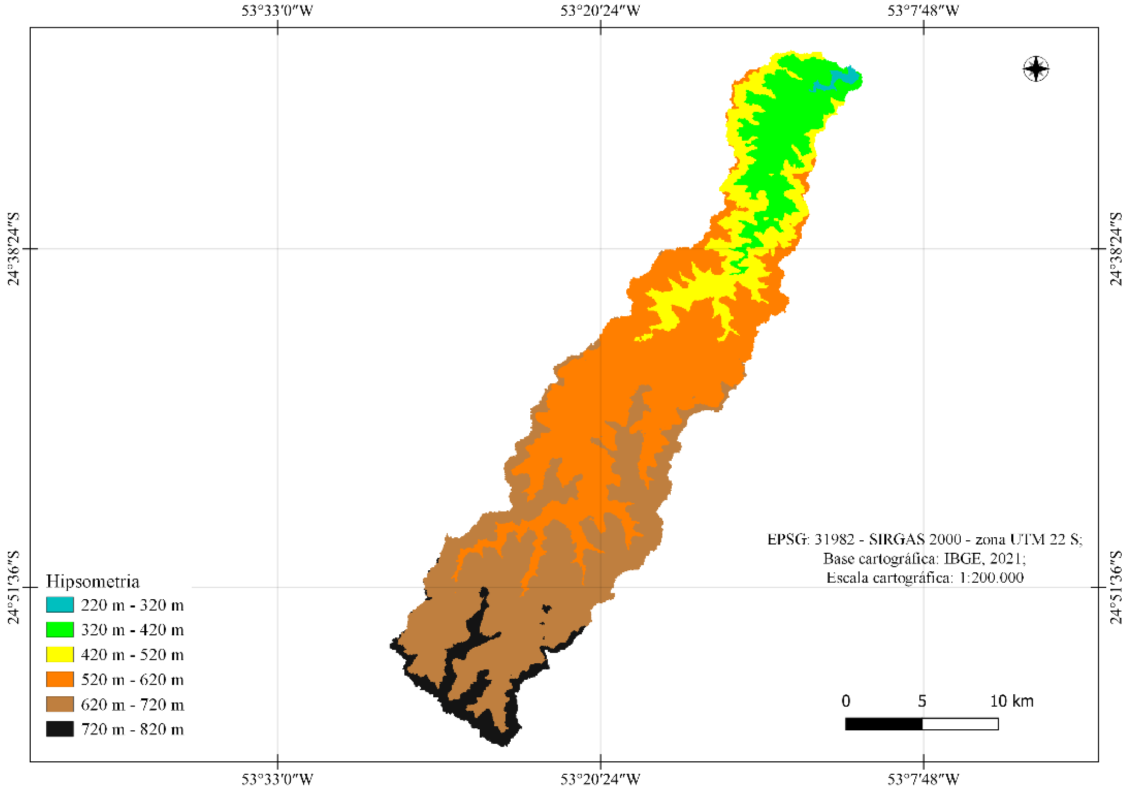
Source: Prepared by the authors, 2025.

The hypsometry of the Melissa River watershed was determined from the distribution of six altimetric ranges, ranging from 220 to 820 m in altitude, as shown in Figure 3. The predominant altimetric range is between 620 and 720 m, with 16,412.553 ha (36.22% of the total area), followed by the range from 520 to 620 m, which occupies 16,327.026 ha (36.04%). The other ranges add up to 12,564.862 ha, representing 27.74% of the area.

According to Francisco *et al*. (2019), the predominant altimetric ranges fall into the category of "low mountains", characterized by gently undulating to undulating reliefs. This geomorphological configuration favors the formation of less steep slopes, reducing susceptibility to erosion and allowing greater stability of the banks.

Figure 3

Hypsometry of the Melissa River watershed, Piquiri River watershed, western region of the state of Paraná, Brazil



Source: Prepared by the authors, 2025.

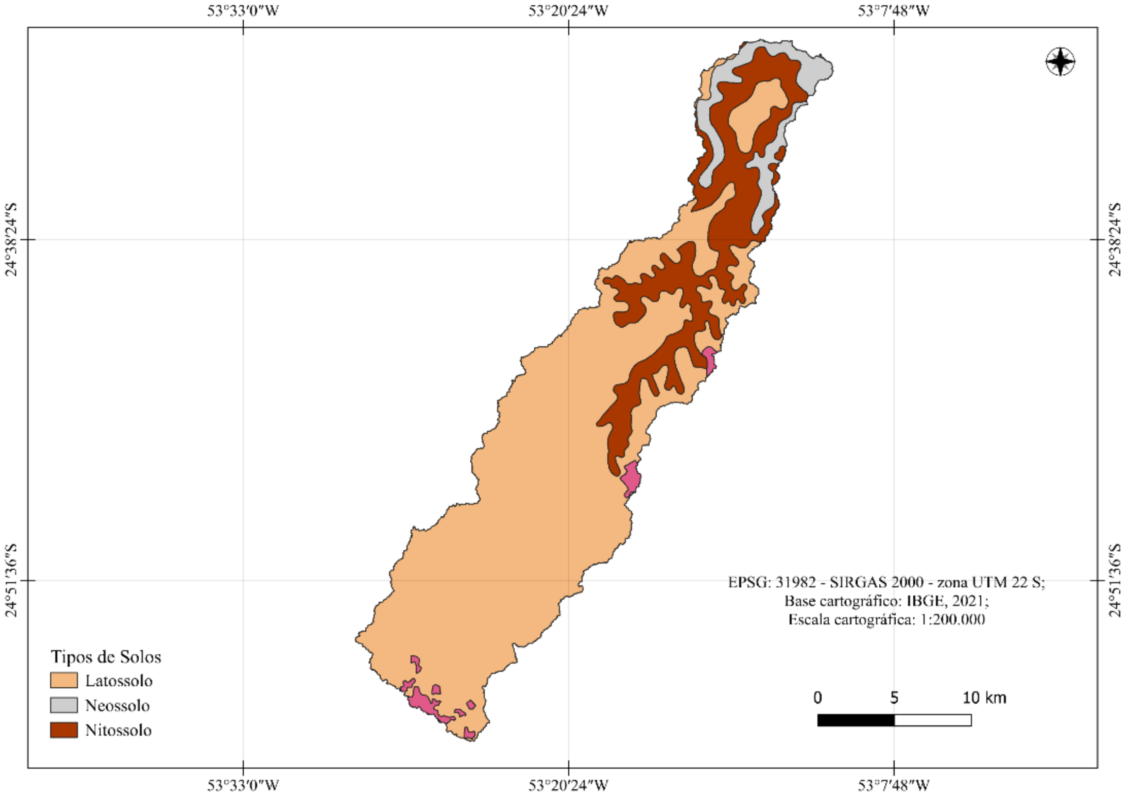
In the Melissa River watershed, three soil classes were identified, as illustrated in Figure 4. The RED LATOSOL predominates, occupying 33,413.17 ha (75% of the total area), followed by the RED NITOSOL, with 8,671.94 ha (19.46%). Both have a high clay content, a characteristic that favors impermeability and increases the structural cohesion of the soil. The lowest occurrence is of the REGOLITIC NEOSOL, with 2,467.41 ha (5.54%), generally associated with areas of steeper relief and lower profile depth.

OXISOLS and NITOSOLS predominate in smooth to undulating relief, ensuring stability for earthworks and good water retention, suitable conditions for fish farming. For the construction of nurseries to be viable, the soil must be impermeable and easy to remove, characteristics of clay soils, which have high plasticity and resistance to erosion (SOUZA, 1999; LIMA et al., 2015), these types of soil are predominant in the watershed.

In addition, the predominance of clay soils contributes to the minimization of water losses by infiltration, facilitating the water management of nurseries. These conditions favor the maintenance of adequate water levels and productive efficiency in fish farming.

Figure 4

Types of soils found in the Melissa River watershed, Piquiri River watershed, western region of the state of Paraná, Brazil



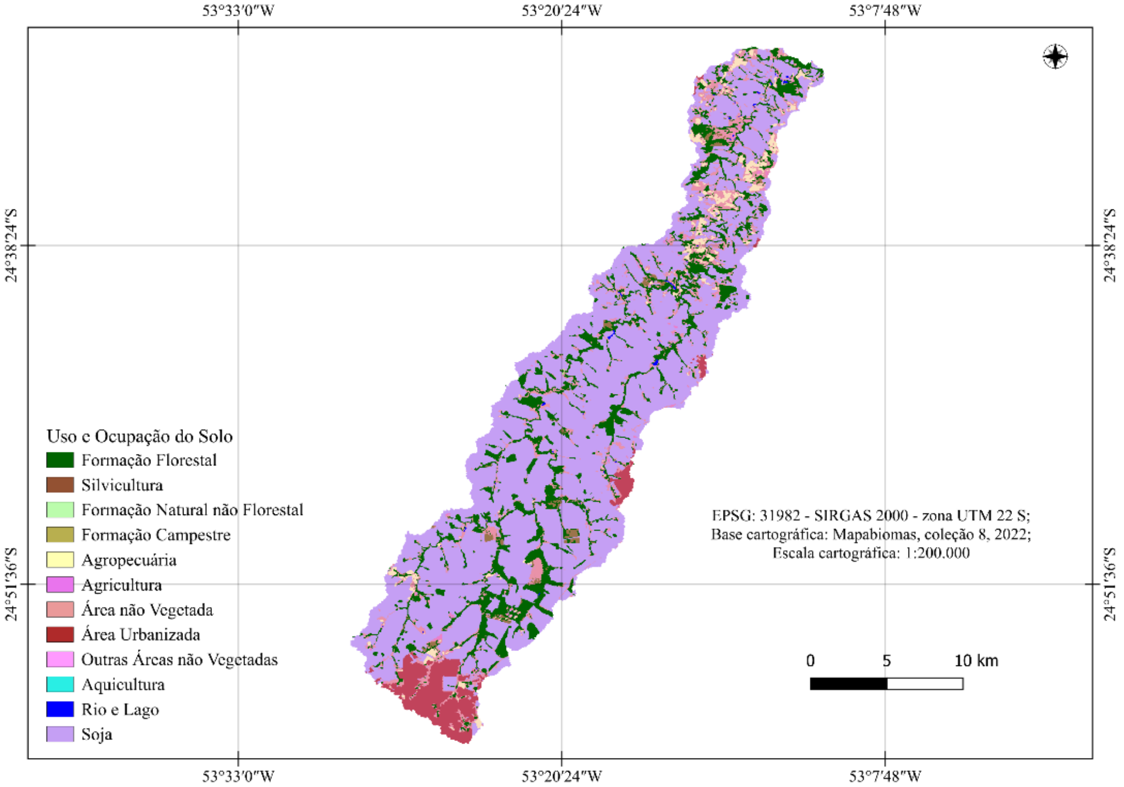
Source: Prepared by the authors, 2025.

The use and occupation of the land demonstrates the various uses that the soil of the Melissa River watershed has, as shown in figure 5. With a predominance of soybean cultivation (63.65%), followed by forest formation (15.65%), mosaic use (9.09%), urban areas (4.88%) and other uses (6.73%). Compared to the data of Junior and Silva (2015), there is a reduction of 2.35 percentage points in forest vegetation (18%) and an increase of 7.65 percentage points in the cultivated area (56%), reflecting the intensification of agriculture in the region studied.

This expansion of agricultural areas, especially soybeans, can increase the mobilization of sediments and nutrients to watercourses, favoring siltation and eutrophication processes. Such impacts require attention in the water management of the watershed, as they directly influence the water quality and the sustainability of fish farming in excavated ponds.

Figure 5

Types of use and occupation of the Melissa River watershed, Piquiri River watershed, western region of the state of Paraná, Brazil



Source: Prepared by the authors, 2025.

Regarding the morphometry of the Melissa River watershed, it has an area of 453 km², with a set of channels of 404,829 m, with the main river having a length of 96,078.68 m. The amplitude of the microbasin is 501 m, the minimum elevation of 288 m, the average elevation of 585 m and the maximum elevation of 789 m of altitude.

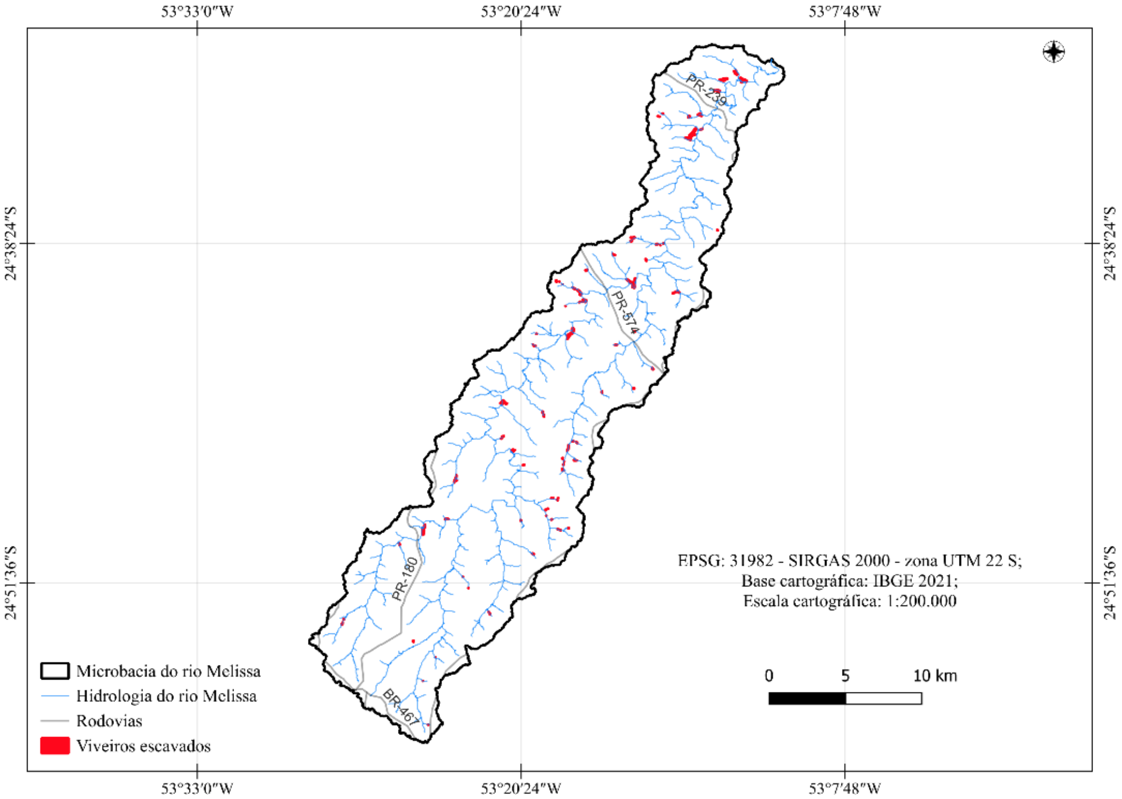
The results of the morphometric indices (Kc = 2.73; F = 0.16; CI = 0.13; Er = 0.44) indicate that the watershed has an elongated shape, with a tendency to conservation and a low risk of flooding (DA CONCEIÇÃO DORNELLAS, 2020), with a pattern similar to that of the Guaçu River (WERNECK, 2024a). The drainage density value (Dd = 0.89) shows low surface runoff and greater water infiltration into the soil, similar to the São Camilo River (MACEDO et al., 2024). The watershed has a sinuous class (Is = 44.05), comparable to that observed in the Santa Quitéria River (PANZERA et al., 2024). The time of concentration of the waters in the basin is 17 h and 30 min. The relief ratio obtained was 0.002, and closer to 0 indicates a predominantly flat relief, as also observed in the Jesuit River (WERNECK et al., 2024b).

278 excavated nurseries were mapped, divided into 3 classes: small, medium and large nurseries, the highways present in the micro-basin were also mapped, namely PR 239, PR 574, PR 180, PR 467, in addition to other side roads, totaling 78.95 km in length. The excavated nurseries and highways are geographically shown in Figure 6.

Fish production in the Melissa River watershed may be directly related to the production incentive for the slaughterhouse of the Consolata Agroindustrial Cooperative (Copacol), since the company carries out integrated activities that include fish farming in vertical fish farming systems (BRUN and AUGUSTO, 2015).

Figure 6

Excavated nurseries and highways located in the watershed of the Melissa River, western region of the state of Paraná, Brazil



Source: Prepared by the authors, 2025.

Among the ponds in the watershed, class I is the most abundant, with 197 excavated ponds, corresponding to 70.86% of the total, as was also observed in the Baiano river watershed (ARAUJO et al., 2025). A total of 87.46 ha of water depths were obtained in the watershed, with class III being the most representative, with 46.01 ha, corresponding to

52.60% of the total water depth, as also observed in the Jesuítas River (WERNECK et al., 2024b), as shown in Table 3.

The predominance of class I nurseries in the region is associated with the presence of small family producers, who opt for smaller structures due to land limitations and lower initial investment costs.

Table 3

Excavated nurseries and water depth located in the watershed of the Melissa River, western region of the state of Paraná, Brazil

Class	Size (m²)	No. of nurseries	% Nurseries	Nursery area	% nurseries
I	300 to 3000	197	70,86	24,84	28,40
II	3001 to 6000	40	14,39	16,61	19,00
III	>6001	41	14,75	46,01	52,60
Total		278	100	87,46	100

Source: Adapted from Werneck et al. (2023).

The total biomass production was estimated at 4,373 t of fish per hectare, and the nutrient input during the rearing period was 199.66 tons (N = 177.86 and P = 21.80, respectively). During harvesting, the nutrient input was 8.51 tons (N = 7.11 and P = 1.40, respectively). In both periods — rearing and harvesting — the nutrient intake was higher in class III, as shown in Table 4. The N/P contribution ratio was 8/1 during rearing and 5/1 during harvesting; both ratios are considered low, as also observed in the Guaçu River (WERNECK et al., 2024a).

Table 4

Total Nitrogen (N) and Total Phosphorus (P) input estimated during rearing and harvesting in excavated ponds in the Melissa River watershed, western Paraná, considering a density of 5 kg of fish per m² over nine months

Class	Biomass (Ton/ha)	Area (ha)	Creation		Fishing	
			N (Ton)	P (Ton)	N (Ton)	P (Ton)
I	1.242	24,84	50,86	6,51	1,36	0,41
II	830,5	16,61	32,41	3,28	2,00	0,43
III	2.300,5	46,01	94,59	12,01	3,75	0,56
Total	4.373	87,46	177,86	21,80	7,11	1,40

Source: Adapted from Coldebella (2020).

These two eutrophicating nutrients are the most impactful in fish farming, but it is important to highlight other elements that influence the carrying capacity of aquatic ecosystems, such as the organic matter deposited in the ponds and the suspended solids released in the receiving bodies, especially in harvesting, as these also affect the metabolism of these aquatic environments (COLDEBELLA et al., 2020; SÁ, 2023). In fish farms, excess nutrients occur due to high stocking density, excessive feed supply, and intensive fertilization, which increase the levels of nitrogen and phosphate compounds in the water (ALCÂNTARA et al., 2017).

4 CONCLUSION

The study of the Melissa River watershed showed a predominantly flat relief, with altitudes between 220 and 820 m, favorable conditions for the establishment of excavated ponds and aquaculture production. Three main soil classes were identified: RED NITOSOL, RED LATOSOL and REGOLITIC NEOSOL, with physical properties that ensure impermeability, structural cohesion and adequate water retention for fish farming. Land use is mostly focused on soybean cultivation, followed by significant aquaculture activity, with 278 excavated ponds mapped and classified in different sizes.

The nutrient intake was higher during the rearing phase (199.66 t) compared to the harvesting (8.51 t), with ponds with an area greater than 6,000 m² being the main responsible for nitrogen and phosphorus loads. These data highlight the need for proper management and spatial planning of fish farming, in order to reduce environmental impacts, avoid eutrophication and promote the sustainability of the aquatic ecosystems of the watershed.

Finally, the results of the study provide technical subsidies to guide future expansions of fish farming in the region and contribute to the conservation and sustainable use of water resources in the Melissa River watershed.

ACKNOWLEDGMENTS

The present work was carried out with the support of CAPES, an entity of the Brazilian Government focused on the training of human resources. We also reinforce the role of CNPq in providing a scholarship to the first author and to Cernupi for the scholarship to the second author. This work is also dedicated to the memory of Mauricio Spagnolo Adames, who was an exemplary fisheries engineer, whose dedication inspires and to his daughter Melissa, whose name is intertwined with that of the river that motivated this research.

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