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Landscape homogenization index: Piripkura's indigenous territory case study and surrounding Census Sectors

Índice de homogeneização da paisagem: estudo de caso TI Piripkura e Setores Censitários do entorno

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Abstract: The Amazon represents the largest biome in Brazil, taking a prominent position in the global context. The increase in agricultural activities and the unrestrained extraction of natural resources put the maintenance of this natural environment at risk, introducing new cultural habits centered on urban life. This consolidates the homogenization of the landscape, which can be observed from the consequences of human activity. In this context, Indigenous Lands act as "shields", protecting their people, biodiversity, carbon stocks and ecosystem services. The Indigenous Lands of Isolated Peoples refer to the territories of indigenous people who do not have direct contact with society in general, and consequently, their territories suffer more significant harassment for invasion and exploitation of natural resources. This research proposes a Landscape Homogenization Index - IHP, based on the territory of isolated indigenous people: Piripkura Indigenous Land, and the Census Sectors in its interior and surroundings, in order to provide subsidies for decision-making and territorial planning. In general, the application of this index demonstrated a higher IHP in areas close to highways, urban centers and with greater population density. In contrast, areas of Conservation Units and Indigenous Lands presented a lower index.

Keywords: Landscape homogenization; Piripkura; Census Sectors.

Resumo: A Amazônia representa o maior bioma do Brasil, assumindo uma posição proeminente no contexto global. O incremento das atividades agropecuárias e a extração dos recursos naturais de forma desenfreada põem em risco a manutenção desse ambiente natural, introduzindo novos hábitos culturais centrados na vida urbana. Consolida-se, assim, a homogeneização da paisagem, que pode ser observada a partir das consequências da atividade humana. Nesse contexto, as Terras Indígenas atuam como "escudos", protegendo seus povos, a biodiversidade, os estoques de carbono e os serviços ecossistêmicos. As Terras Indígenas de Povos Isolados referem-se aos territórios de indígenas que não possuem contato direto com a sociedade em geral e, consequentemente, seus territórios sofrem maior pressão para invasão e exploração de recursos naturais. Essa pesquisa propõe um Índice de Homogeneização da Paisagem (IHP) voltado para espaços de indígenas isolados, neste caso a Terra Indígena Piripkura, e os Setores Censitários em seu interior e em seu entorno, a fim de fornecer subsídios para a tomada de decisões e planejamento territorial. De maneira geral, a aplicação desse índice demonstrou maior IHP em áreas próximas a rodovias, sedes urbanas e com maior densidade populacional, enquanto áreas de Unidade de Conservação e Terras Indígenas apresentaram um índice menor.

Palavras-chave: Homogeneização da paisagem; Piripkura; Setores Censitários.

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1. Introduction

The Amazon represents the largest biome in Brazil, encompassing a territorial extension of approximately 4.2 million km² (BRAZIL, 2023). This places it in a prominent position globally, given the vast expanse of tropical forest worldwide, as well as its rich biological diversity and large areas still preserved. However, this biome faces a progressive increase in anthropogenic tensions, meaning pressure resulting from human activities in a specific geographic environment (SANTOS et al., 2018).

Starting from colonization policies implemented by military governments during the 1960s, the tension scenario has evolved drastically in the biome. A new spatial pattern emerged, characterized by the expansion of agricultural frontiers, supported by monocultures, aligned with the construction of highways and the implementation of territorial occupation projects. These forms of economic activity expansion and territorial occupation follow a homogenizing pattern, disregarding forest conservation and its communities, resulting in the loss and degradation of Amazonian ecosystems. Furthermore, it neglects the existence of local communities and their ancestral traditions of life and subsistence, making any forest preservation strategy impractical, resulting in the loss of practical knowledge and technologies developed by these communities, as well as their sustainable and productive methods of living with the forest (ESCADA et al., 2023). The increase in agricultural activities as the predominant land use, as well as the expansion of mechanized soybean farming, mining, timber exploitation, illegal land grabbing, land speculation, and road construction, jeopardize the maintenance of these natural environments, introducing new cultural habits centered on urban life (ALMEIDA et al., 2022). By 2020, according to data from Brazil (2023), 729,781.76 km^2 of the Amazon Biome and 813,063.44 km^2 in the Legal Amazon had been deforested, corresponding to 17% of the total area of this biome.

Within this reality, Indigenous Territories (IT) currently occupy a total extension of nearly 1.17 million km^2 in Brazil (RIZEK, 2022), with the vast majority in the Amazon territory, covering 27% of the biome. Furthermore, according to Rizek (2022), these territories act as "shields," protecting their peoples, biodiversity, carbon stocks, and ecosystem services. In this context, Indigenous Territories are under constant pressure from threats associated with the homogenization processes of the landscape, considering a dependent capitalist society model.

Regarding landscape homogenization, an initial approach can be made by considering the consequences of human activity. In this sense, one of the causes of homogenization is the anthropogenization of the landscape, which refers to the modification of the structure, functioning, dynamics, information, and even evolutionary trends of the original landscape due to human intervention (RODRÍGUEZ, 1991). When this structure changes and a new invariant pattern is established, this process is known as anthropogenic transformation of the landscape, resulting in the formation of anthropic or anthro-natural landscapes (RODRÍGUEZ, 1991).

Magalhães (2010) indicates that increasingly studies on landscape anthropogenization have shown that human influence on nature is not only an intrinsic characteristic of its existence but also a fundamental part of the collective evolution process of species, how they interact with each other, exchange influences, and consequently evolve together, according to their specific characteristics. Therefore, a natural environment should not be considered a "barrier to human adaptation" (MAGALHÃES, 2010, p. 411).

From this perspective, Balée (1995) demonstrated that contemporary traditional ethnic societies also play an active role in modifying the environments they live in, resulting in increased productivity and diversification of vegetation. Magalhães (2016) suggests through archaeological records from 3.500 years ago that at least 60% of the total non-floodable lands available in the Amazon had already been modified by human activity and were culturally recognized.

Therefore, based on this perspective of the intrinsic relationship between humans and nature that indigenous peoples possess, a difference in social and cultural structure is observed compared to western societies, since the latter often have a predatory approach to landscape transformation. When discussing the pressure faced by indigenous peoples due to homogenization processes and consequent anthropogenesis of the landscape, it is important to consider their preservationist lifestyle. Thus, by mentioning the tensions that these peoples face in relation to landscape homogenization processes, this research does not intend to exclude or ignore them, but rather values and considers their way of life, since their activity results in almost insignificant negative impacts on landscape transformation and positive impacts on tropical ecosystem management.

From this point of view, as Amazonian anthropogenesis and indigenous peoples have cooperatively altered the landscape over time, the contemporary process of landscape homogenization considers a modification that pertains to a harmful structural standardization to sustainability.

Stavenhagen (1985) discusses the concept of ethnodevelopment applied to traditional communities as an alternative development approach that preserves the sociocultural identity of a society, i.e., its ethnicity. Thus, development has little

or no relation to usual "progress" indicators such as GDP, per capita income, infant mortality rate, educational level, among others.

In Brazil, article number. 231 of the 1988 Constitution (Brazil, 1988, p. 133) recognizes aspects of the social organization, habits, customs, traditions, and cultural differences of indigenous peoples, guaranteeing them the right to preserve their culture, identity, and way of life. Therefore, the demarcation process of Indigenous territories is configured as a fundamental instrument in ethno-environmental preservation, that is, in the subsistence of the indigenous way of life and the environment. Demarcation serves to curb deforestation and invasion by land grabbers and loggers in the areas of isolated peoples. When traditional territories are vulnerable and have not yet been demarcated, the State, through the indigenous agency, uses the legal device of "use restriction." In the territorial classification of Indigenous Territories, Indigenous Territories of Isolated Peoples refer to the territories of indigenous peoples that do not have direct contact with society at large. According to Funai (2020), the designation of "isolated indigenous peoples specifically refers to indigenous groups with an absence of permanent relations with national societies or with little frequency of interaction, either with non-indigenous people or with other indigenous peoples."

The contact between indigenous peoples and the surrounding society throughout history has been a traumatic process. Many conflicts arise from differences in the conception and experience of the territory. According to Funai, the model adopted by the State and economic development initiatives have caused significant changes in the pattern of land use and occupation and in the exploitation of natural resources (FUNAI, 2013).

This view allows us to understand that the territory, before being a consolidated fact, is actually a relationship. Therefore, it is subject to instabilities and positions that may not be in agreement. The constituent elements that sustain it are also not fixed or absolute. Territoriality, which is the generating principle of the territory and is not yet completely consolidated, finds its possibility of existence in the creation of ties between the actor (individual or group) and the space (territory) (HEIDRICH, 2008).

The study conducted by Lopes and Souza (2020) highlights the importance of establishing protective zones around Indigenous Territory to safeguard their interior. By implementing laws that protect surrounding areas, a reduction in deforestation activities within these territories was observed. Furthermore, Lopes and Souza (2020) emphasize that the adjacent areas to Indigenous Territory face high rates of deforestation, primarily due to the lack of buffer zones, similar to those in Conservation Units.

In this context, the Piripkura Indigenous Territory is currently under use restriction, which imposes limitations on the access, movement, and presence of non-FUNAI personnel. To maintain this status, a decree is issued every two years renewing the restriction period. This legal measure has been in place since 2008. However, in March 2023, Ordinance No. 625, dated March 7, 2023 (BRASIL, 2023), ensures restricted access to the Piripkura territory until the homologation of its demarcation is published.

The dossier titled "Piripkura: An Indigenous Territory Devastated," produced by the Socio-Environmental Institute (ISA, 2021), reveals that deforestation in the region between 2020 and 2021 totaled 2,361 hectares. As of October 21, 2021, cumulative deforestation in the Indigenous Territory reached 12,426 hectares, corresponding to the felling of over 7 million trees (ISA, 2021). This assessment was conducted by ISA's independent system (Sirad), using data from the Monitoring of Deforestation in the Brazilian Amazon Forest by Satellite (Prodes), developed by the National Institute for Space Research (INPE) (ISA, 2021).

Thus, preserving the areas inhabited by Indigenous groups is essential to creating the necessary conditions for these communities, particularly those seeking isolation, to maintain their connection to their territory. In this regard, the demarcation processes of Indigenous Territory, alongside monitoring the pressures on already established territories, are fundamental tools for ethno-environmental preservation. Demarcation serves to limit deforestation and prevent invasion by deforesters in areas of isolated peoples.

Given the restriction of contact in remote areas inhabited by isolated Indigenous groups, such as the Piripkura Indigenous Territory, conventional tools like ethnomapping and ethno-zoning of their way of life become impractical. Therefore, the use of Geographic Information Systems (GIS) becomes essential for generating information and providing support for the demarcation process.

To measure the levels of socio-environmental transformations and degradation, various evaluative approaches based on socio-environmental indicators have been developed to quantify and analyze different ecosystems under various types of impacts. Silva and Ribeiro (2004) assessed the current stage of degradation in municipalities within the state of Acre by grouping them into clusters with similar characteristics through the development of a Degradation Index (ID). Brandão (2005) applied an Environmental Degradation Index (IDA), describing levels of environmental degradation through interactive diagnostics, also evaluating natural resources and their interaction with human activities. Pinto et al. (2016)

developed a Degradation Index (ID) using multivariate analysis, specifically factor analysis, to measure environmental degradation across Brazilian states and regions.

Aguiar (2012) applied spatial regression models to analyze factors associated with land-use changes in the Amazon, related to deforestation, grazing, and temporary and permanent agriculture. This study grouped potential explanatory variables into seven categories: market accessibility, economic attractiveness, demography, technology, land structure, public policies, and environmental factors. One of Aguiar's conclusions was that deforestation commonly occurs near highways, as these facilitate access to forest areas and connect to more developed regions of Brazil (AGUIAR, 2012).

Given this context, this research aims to develop a tool based on Geographic Information Systems (GIS) that uses secondary data to assist in the demarcation, environmental management, and territorial planning of areas inhabited by Indigenous peoples without contact with civil society. This will involve analyses of anthropogenic pressures, using variables related to infrastructure, land structure, demography, and mining claims. To this end, the research proposes the development of a Landscape Homogenization Index based on the Piripkura Indigenous Land and the Census Sectors within and around it, to support decision-making processes for territorial planning in isolated Indigenous territories.

2. Methodology

The Piripkura Indigenous territories (Figure 01) is located in the municipalities of Colniza and Rondolândia in the northwest of Mato Grosso, with an approximate area of 242,500 hectares and a perimeter of 284 kilometers. The region is surrounded by farms and illegal loggers, which constitutes a context of intense agrarian conflicts, keeping the indigenous population under constant threat of confrontation.

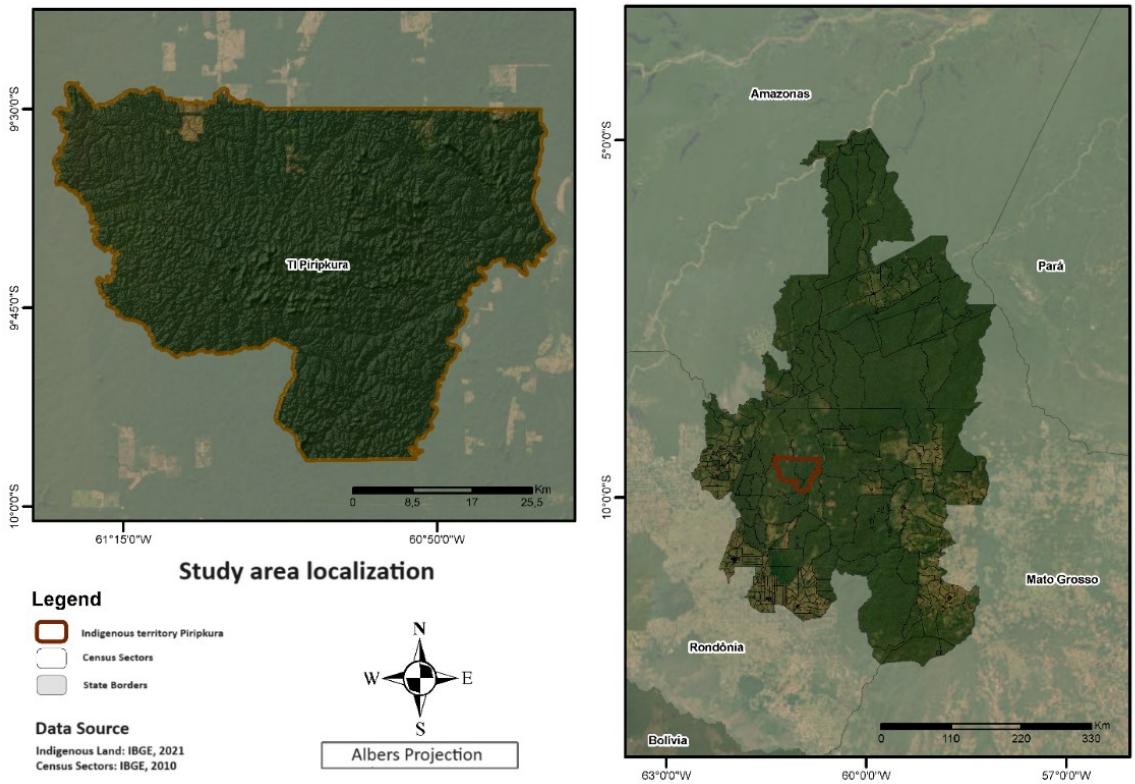

Figure 01 – Location of the Study Area.
Source: Authors (2023).

From the context of the IT inhabited by this isolated ethnic group, a study area was delineated based on census sectors (IBGE, 2022) of the municipalities where the Pirikura Indigenous Territory is located, as well as the municipalities

bordering Colniza and Rondolândia. Consequently, the study area encompasses a total of 741 census sectors, covering the cities of Apuí/AM, Novo Aripuanã/AM, Aripuanã/MT, Colniza/MT, Cotriguaçu/MT, Juina/MT, Rondolândia/MT, Cacoal/RO, Espigão d'Oeste/RO, Ji-Paraná/RO, Machadinho d'Oeste/RO, Ministro Andreazza/RO, and Vale do Anari/RO. Census sectors were used as the surrounding area of the Piripkura IT, as they constitute the smallest portion of territorial organization within the census conducted by IBGE. All data geoprocessing analyses were performed using ArcGIS and ArcGIS Pro software.

To formulate a socioenvironmental indicator, the conception of an index evaluating the degree of landscape homogenization was developed, that is the susceptibility to transforming the forest into a landscape based on an industrialized society shaped by natural resource exploitation. In this sense, the Landscape Homogenization Index - LHI was developed, based on spatial data cross-referencing through the application of multicriteria analysis, using the Analytic Hierarchy Process (AHP) methodology, to assign different weights to variables related to human activities involving interference with natural resources, such as road infrastructure, mining requirements, land structure, census sectors, among others.

For the application of this analysis, the listed variables are presented in Table 01, considering that deforestation patterns (an example of homogenization) in the Amazon are typically associated with large-scale livestock farming, mineral exploitation, road infrastructure, and anthropic densification.

Table 01 – Description of Variables.

Description of the analyzed variables			
Level of importance	**Variables**	**Description**	**Unit**
1	Vegetation Cover;	Vegetation cover here was adopted as an indicator of forest degradation, where areas with higher vegetation cover are considered more preserved.	% area
2	Distance to Highways;	Being pathways for natural resources drainage, the road and hydrographic networks were measured, considering that the greater the distance from the IT to highways and rivers, the lower the probability of degradation.	Average kilometer
3	Distance to Rivers;		
4	Land Structure;	Data from the Rural Environmental Registry.	Average hectare
5	Indigenous territory;	Due to the vegetation cover preservation capacity in these areas, the higher the percentage of areas related to Indigenous territory and Conservation Units, the lower the probability of degradation.	% area
6	Conservation Units;		
7	Population Density;	Data associated with census sector, where population density represents the number of people per hectare, and income considers income per capita.	Population Number
8	Income;		Brazilian real currency
9	Distance to Urban Centers;	Considering urban centers as urbanized and consequently homogenized areas, the distance to urban centers was measured, so features located close to urban areas are more prone to homogenization.	Average kilometer
10	White Population;	The white population serves as an indicator of large landholdings that emerged from the 1970s due to migration of people from the state of Rio Grande do Sul to the states of the Legal Amazon.	Brazilian real currency
11	Mining Permits	Mining permits related to requests for mineral exploration. Therefore, the percentage of these areas was considered.	% area

Source: Authors (2023).

Initially, data collection was conducted. For raster data, the data were extracted from MapBiomas (MAPBIOMAS, 2022) for 2020 with a resolution of 30 meters, which underwent binary reclassification treatment to determine vegetation

cover, with one (1) representing vegetation cover and zero (0) representing land use. Vector data were extracted from geospatial databases of public agencies such as IBGE, SNIRH, SIGMINE, SICAR, FUNAI, and ICMBio.

The analysis of land structure considered data from the Rural Environmental Registry (CAR), an electronic record filled out by landowners themselves. Due to the self-declaration nature of CAR, many landowners claim ownership of others' properties or overlap their hypothetical areas with Conservation Units and Indigenous Territory. Therefore, for this category, due to the overlay of vector information resulting from the self-declaration nature of CAR, a refinement of records related to extensive areas overlapping multiple registrations (CAR) was performed, following the methodology adaptation by Rajão et al. (2020).

For the generation of data on "distance to highways," "distance to rivers," and "distance to urban centers," from vector files, Euclidean distance analysis was applied to calculate the distance from the nearest features to the input data. For "vegetation cover," "zonal statistics" were performed to calculate the area of pixels from the reclassified MapBiomas raster within the census sectors. Data on census sectors, population density, income, and white population were extracted from the IBGE Census of 2010 (IBGE, 2022), as data from the latest IBGE Census of 2022 had not yet been published at the time of data processing, and have not been fully available to date. Data on "land structure," "Indigenous Territory" and "Conservation Units" were calculated using the Summarize Within vector tool in ArcGIS Pro, which measures the total area of these polygons within the census sectors.

To visualize all analyses conducted before applying the Analytic Hierarchy Process - AHP, Figure 02 presents the spatialization of the 11 variables used.

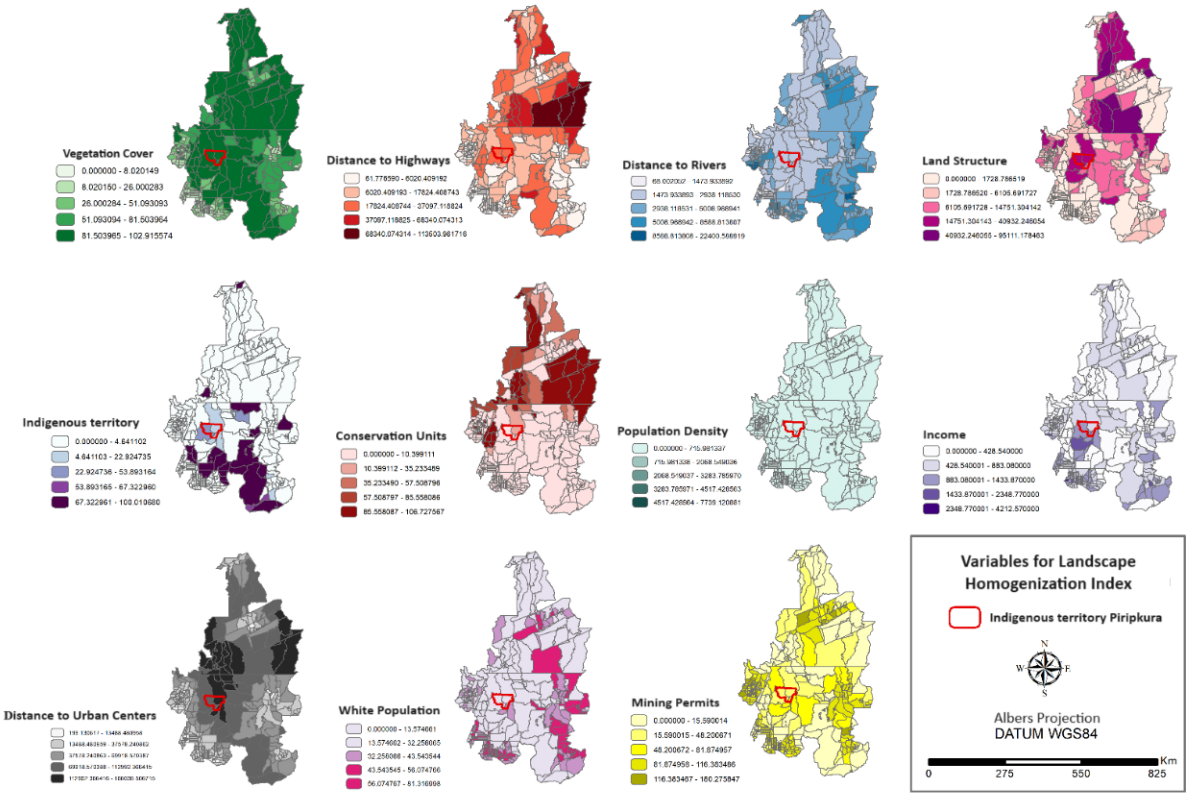

Figure 02 – Spatialization of the analyses performed for the index variables.
Source: Authors (2023).

It is important to highlight that variables such as vegetation cover, distance to highways, distance to water bodies, Indigenous Terrirories (IT), Conservation Units (CU), and distance to urban centers underwent a reversal of values before being incorporated into the multicriteria statistical analysis. This occurred because as vegetation cover increases and the

presence of IT and CU grows, the susceptibility to landscape homogenization decreases. Similarly, the closer the distance to urban centers, highways, and water bodies, the greater the susceptibility to landscape homogenization.

Thus, for the implementation of the AHP statistics, based on criteria from the literature, a hierarchy level was established for the variables, with the first having the highest level of importance and the last having the lowest level.

The application of AHP generated a correlation matrix by assigning importance degrees (weights) to the variables, ranging from 1 to 9, where the weight "1" indicates that the variables have the same importance and is automatically assigned when the variables are identical. To apply the AHP method to the chosen variables, the AHP-OS website (GOEPEL, 2022) was used to compose the paired decision matrix (Table 02), generating a Consistency Ratio (CR) of 4.1%.

Table 02 – Paired decision matrix of the AHP method.

	Variables										
Título	**Veg.Cover**	**Dist. Highways**	**Dist. Rivers**	**Land Structure**	**Indigenous territory**	**Conservation Units**	**Population Density**	**Income**	**Dist. Urban Centers**	**White Pop.**	**Mining Permits**
Veg.Cover	1	3.00	4.00	5.00	6.00	6.00	7.00	7.00	7.00	7.00	8.00
Dist. Highways	0.33	1	3.00	4.00	5.00	5.00	7.00	7.00	7.00	7.00	8.00
Dist. Rivers	0.25	0.33	1	2.00	3.00	3.00	4.00	4.00	4.00	4.00	6.00
Land Structure	0.20	0.25	0.50	1	2.00	2.00	4.00	4.00	4.00	4.00	6.00
Indigenous territory	0.17	0.20	0.33	0.50	1	1.00	3.00	3.00	3.00	3.00	5.00
Conservation Units	0.17	0.20	0.33	0.50	1.00	1	3.00	3.00	3.00	3.00	5.00
Population Density	0.14	0.14	0.25	0.25	0.33	0.33	1	1.00	1.00	1.00	3.00
Income	0.14	0.14	0.25	0.25	0.33	0.33	1.00	1	1.00	1.00	3.00
Dist. Urban Centers	0.14	0.14	0.25	0.25	0.33	0.33	1.00	1.00	1	1.00	3.00
White Pop.	0.14	0.14	0.25	0.25	0.33	0.33	1.00	1.00	1.00	1	3.00
Mining Permits	0.12	0.12	0.17	0.17	0.20	0.20	0.33	0.33	0.33	0.33	1

Source: Authors based on the AHP decision matrix (2023).

Based on the relevance level assigned to each variable, the following operation was performed to calculate the AHP for each census sectors (Formula 1):

(Veg.Cover*0.31) + (Dist. Highways *0.224) + (Dist. Rivers *0.119) + (Land Structure*0.092) + (Indigenous territory *0.063) + (Conservation Units *0.063) + (Population Density *0.029) + (Income *0.029) + (White Pop *0.029) + (Dist. Urban Centers *0.029) + (Mining Permits *0.016) (1)

Following that, as each variable had a different unit of measurement, the values were normalized. For each variable, the LHI value of each census sector portion/vector was subtracted from the smallest LHI value found in the analysis of all variables. Then, these values were divided by the subtraction of the largest from the smallest IHP value found. The operation performed can be observed through Formula (2).

$$LHI\ normalized = LHI - LHIminimum\ /\ LHI\ maximum - LHIminimum \quad (2)$$

Finally, the results ranged between zero (0) and one (1), with values closer to one (1) indicating greater landscape homogenization.

3. Results and Discussion

From the generation of the Landscape Homogenization Index for the 741 census sectors, including the Piripkura Indigenous Territory, considering that values closer to one (1) represent more homogenization of the landscape and its anthropogenic processes, values were obtained where the maximum value was 0.99, corresponding to the urban center of the municipality of Ji-Paraná, the mean was 0.92, and the minimum value was 0.06, corresponding to an area within three Conservation Units, namely: Sucurundi State Forest, Sucurundi State Park, and Apuí State Forest.

The Piripkura Indigenous Territory area comprises three census sectors, which presented landscape homogenization index values of 0.76, 0.78, and 0.82. Based on these indices, and considering previous knowledge, it is understood that, due to its relatively close proximity to urban areas, the significant presence of Rural Environmental Registry (CAR) around it and overlapping its territory, as well as its relative adjacency to highways and waterways, and considering the territorial pressures exerted, the index is balanced with reduced values of vegetation cover, resulting in a range of variation between 0.76 and 0.82.

Overall, it seems that the composition of this index demonstrates efficiency as expected results were confirmed. Urban centers exhibited a high landscape homogenization index, while areas designated as socioecological refuges, such as Conservation Units and Indigenous Territories, showed lower indices, mainly due to the higher relevance weight: the percentage of vegetation cover. Thus, it can be inferred that in regions with lower landscape homogenization, there is effectively a greater presence of vegetation cover and, as a result, a lower occurrence of deforestation and other land cover uses.

The proximity of highways, waterways, and mining concessions ends up conferring a slight increase in population density in census sectors covering Indigenous Territories. Considering that these regions play a crucial role in ethnic-cultural and forest preservation, the index values maintain an average with a considerable range from one (1), but far from zero (0), due to the counterposition.

These results corroborate with what was observed by Alves (2002), where it is inferred that the deforestation process concentrates around the main highways, forming more extensive deforested areas. Likewise, Santos (2020) estimates that Indigenous territories and conservation units play an important role in preserving the socio-cultural and ecosystem functions of natural environments, contributing to biodiversity conservation through the regulation of the hydrological cycle. Furthermore, Santos (2020) indicates that these areas play a crucial role in maintaining soil quality and integrity, preserving native vegetation, and retaining carbon stocks, which regulate and stabilize the regional and global climate, as well as combat the adverse effects of climate change.

However, in addition to fulfilling various ecological functions, Indigenous Territories also preserve a way of life that reflects the worldview of the ethnic groups that inhabit them. In general, these communities maintain an intrinsic relationship with nature, where human beings are considered an integral part of ecosystems and nature itself. In this context, they act in the preservation of forests and landscape management in a way that harmonizes with all existing forms of life.

Figure 03 displays the spatial distribution of the Landscape Homogenization Index. Through this image, it is possible to verify that regions with softer shades of green indicate a greater predisposition to homogenization. On the other hand, areas with more intense shades of green are less susceptible, usually corresponding to Indigenous Territories and Conservation Units.

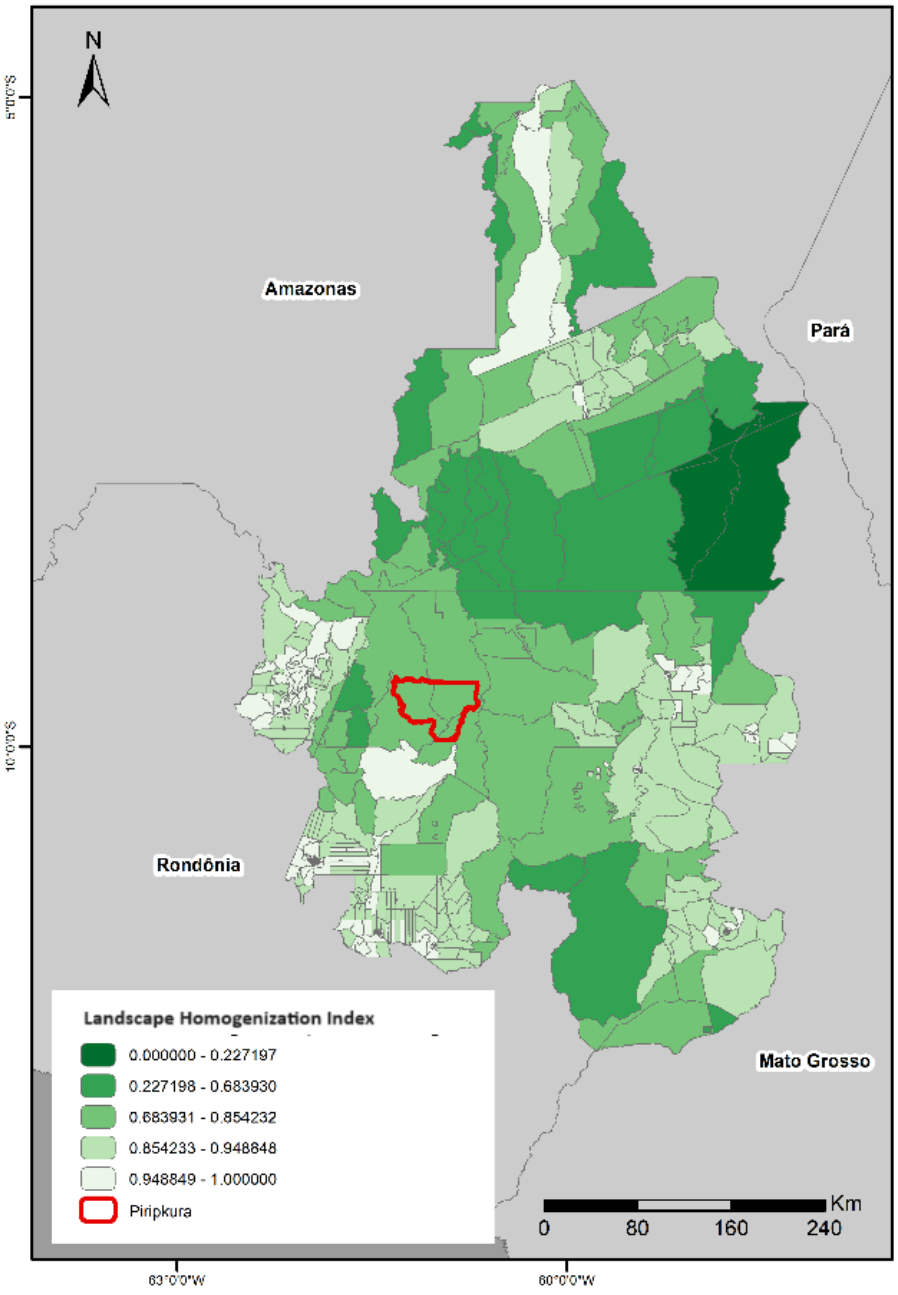

Figure 03 – Landscape homogenization index in the study area.
Source: Authors (2023).

When analyzing the overlap of variables individually, it is observed that proximity to highways, proximity to watercourses, and proximity to urban centers exhibit a correlation where shorter distances are associated with lower vegetation coverage and, consequently, a higher degree of landscape homogenization. Similarly, the evident presence of areas registered in the Rural Environmental Registry (CAR) is also correlated with a higher level of homogenization.

As observed by Rajão et al. (2020) in their research that used CAR as a category of analysis, of the samples analyzed, approximately 162,000 out of 362,000 properties (45%) in the Amazon region and 217,000 out of 452,000 properties (48%) in the Cerrado are not in compliance with the legislation due to deforestation of permanent preservation areas (APP) or lack of conservation of their minimum legal reserves.

In the Brazilian Amazon region, Fearnside (2022) observed that over the years, a significant portion of deforestation originated from large rural properties, often driven by tax incentives and funded by illicit activities. In this context, income becomes an indicator of greater resources for deforestation practices (FEARNSIDE, 2022).

The data presented by Fearnside (2022), together with the results obtained by the index, support the hypothesis that anthropic densification, which in this study includes demographic density, income, and the presence of the white population - considering migratory movements of descendants of Italian and German immigrants from the southern region of the country for the expansion of the agricultural frontier in the Amazon region, tends to be related to extractive activities of natural resources, including deforestation, mineral exploration, and, above all, the formation of large estates.

Based on the analyses conducted and the index demonstrations, the possibility of incorporating new variables later, such as deforestation rates, agricultural activities, occurrences of wildfires, and the capacity for social/media mobilization for territorial demarcation purposes, is considered. The proposal also involves the incorporation of a temporal dimension, allowing the monitoring of changes over a specific period, with the purpose of creating an observatory to monitor landscapes of difficult access, such as those of isolated indigenous territories.

4. Final considerations

Through the conducted analyses, the application of a multicriteria analysis on various variables related to landscape homogenization processes proved to be successful, as the results, in general terms, corroborated the pre-existing expectations, indicating that Indigenous Lands and Conservation Units present lower landscape homogenization indices, while areas near urban centers, highways, watercourses, and with higher population densities revealed higher homogenization indices.

To enhance the effectiveness of this index, so that it can be employed as a tool in processes of demarcation of Indigenous Lands inhabited by isolated peoples, it is proposed to include a temporal dimension, as well as other variables, such as deforestation rates, agricultural activities, incidence of wildfires, and the capacity for social/media mobilization over these territorie.

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