

USE OF GEOPROCESSING AND HISTORICAL PHOTOGRAPHS TO ASSESS THE SUPPRESSION OF VEGETATED AREAS AND SUBSEQUENT INTERPRETATION USING ARTIFICIAL INTELLIGENCE

USO DO GEOPROCESSAMENTO E FOTOS HISTÓRICAS PARA AVALIAÇÃO DA SUPRESSÃO DE ÁREAS VEGETAIS E POSTERIOR INTERPRETAÇÃO COM USO DE INTELIGÊNCIA ARTIFICIAL

USO DEL GEOPROCESAMIENTO Y FOTOGRAFÍAS HISTÓRICAS PARA LA EVALUACIÓN DE LA SUPRESIÓN DE ÁREAS VEGETADAS Y SU POSTERIOR INTERPRETACIÓN MEDIANTE EL USO DE INTELIGENCIA ARTIFICIAL

 <https://doi.org/10.56238/sevened2025.036-127>

Ramon Juliano Rodrigues¹, Alicia de Moraes Campos², Fábio Eder Cardoso³, Edislane Barreiros de Souza⁴, Dario Abel Palmieri⁵, Oscar Peixe da Silva Oliveira⁶, Larissa Tomaz Feltrin Kuronuma⁷

ABSTRACT

The present study employs geoprocessing techniques, automated interpretation using Artificial Intelligence (AI), and historical aerial images to assess urban expansion and the suppression of vegetated areas in the municipality of Assis (São Paulo State, Brazil) between 1960 and 2025. The images were georeferenced and digitized, generating tables that quantify changes in land use over time. AI was applied to the interpretative analysis of these data, enabling the identification of patterns of urban growth, vegetation fragmentation, and environmental changes across decades. An increase in built-up areas and a progressive reduction in vegetation cover were observed, highlighting anthropogenic pressure on local ecosystems. This approach stands out for its low operational cost, since, after obtaining aerial images—often freely available in public databases—the processing and analysis stages are carried out quickly and efficiently. This characteristic assigns geoprocessing a strategic role in territorial management and sustainable urban planning, allowing public managers to understand urban growth dynamics with precision and agility, supporting environmental and land-use policies. The integration of geoprocessing and Artificial Intelligence proved to be an indispensable tool for monitoring spatial transformations, providing real-time environmental diagnostics, and guiding evidence-based decision-making.

¹ Dr. in Agronomy. Universidade Estadual Paulista Júlio de Mesquita Filho (UNESP). São Paulo, Brazil. E-mail: ramon.rodrigues@unesp.br Orcid: <https://orcid.org/0009-0003-1789-299X>

² Graduated in Biological Sciences. Universidade Estadual Paulista Júlio de Mesquita Filho (UNESP). São Paulo, Brazil. E-mail: alicia.morais@unesp.br

³ Dr. in Computer Science. Universidade Estadual Paulista Júlio de Mesquita Filho (UNESP). São Paulo, Brazil. E-mail: fabio.eder@unesp.br Orcid: <https://orcid.org/0000-0002-0309-057X>

⁴ Dr. in Biological Sciences. Universidade Estadual Paulista Júlio de Mesquita Filho (UNESP). São Paulo, Brazil. E-mail: edislane.souza@unesp.br Orcid: <https://orcid.org/0000-0001-7083-5626>

⁵ Dr. in Biological Sciences. Universidade Estadual Paulista Júlio de Mesquita Filho (UNESP). São Paulo, Brazil. E-mail: dario.palmieri@unesp.br Orcid: <https://orcid.org/0000-0003-0841-6257>

⁶ Graduated in Biotechnological Engineering. Universidade Estadual Paulista Júlio de Mesquita Filho (UNESP). São Paulo, Brazil. E-mail: oscaroliveira96@gmail.com

⁷ Graduated in Business Administration. Universidade Estadual Paulista Júlio de Mesquita Filho (UNESP). São Paulo, Brazil. E-mail: larissa.tomaz@unesp.br

Keywords: Geoprocessing. Artificial Intelligence. Vegetation Suppression. Urban Expansion. Temporal Analysis.

RESUMO

O presente estudo utiliza técnicas de geoprocessamento, interpretação automatizada por Inteligência Artificial (IA) e imagens aéreas históricas para avaliar a expansão urbana e a supressão de áreas vegetais no município de Assis (SP) entre os anos de 1960 e 2025. As imagens foram georreferenciadas e digitalizadas, gerando tabelas que quantificam a evolução da ocupação do solo. A IA foi empregada na análise interpretativa desses dados, permitindo identificar padrões do crescimento urbano, fragmentação da vegetação e alterações ambientais ao longo das décadas. Observou-se um aumento das áreas construídas e uma redução progressiva da cobertura vegetal, evidenciando a pressão antrópica sobre ecossistemas locais. Este tipo de abordagem destaca-se por apresentar baixo custo operacional, uma vez que, após a obtenção das imagens aéreas que, em muitas vezes, se encontram disponíveis gratuitamente em bases públicas, as etapas de processamento e análise são realizadas de forma rápida e eficiente. Tal característica confere ao geoprocessamento um papel estratégico na gestão territorial e no planejamento urbano sustentável, permitindo que gestores públicos compreendam a dinâmica de crescimento das cidades com precisão e agilidade, subsidiando políticas ambientais e de uso do solo. A integração entre geoprocessamento e Inteligência Artificial mostrou-se uma ferramenta indispensável para monitorar transformações espaciais, fornecer diagnósticos ambientais em tempo real e orientar tomadas de decisão fundamentadas em evidências.

Palavras-chave: Geoprocessamento. Inteligência Artificial. Supressão Vegetal. Expansão Urbana. Análise Temporal.

RESUMEN

O presente estudo utiliza técnicas de geoprocessamento, interpretação automatizada por Inteligência Artificial (IA) e imagens aéreas históricas para avaliar a expansão urbana e a supressão de áreas vegetais no município de Assis (SP) entre os anos de 1960 e 2025. As imagens foram georreferenciadas e digitalizadas, gerando tabelas que quantificam a evolução da ocupação do solo. A IA foi empregada na análise interpretativa desses dados, permitindo identificar padrões do crescimento urbano, fragmentação da vegetação e alterações ambientais ao longo das décadas. Observou-se um aumento das áreas construídas e uma redução progressiva da cobertura vegetal, evidenciando a pressão antrópica sobre ecossistemas locais. Este tipo de abordagem destaca-se por apresentar baixo custo operacional, uma vez que, após a obtenção das imagens aéreas que, em muitas vezes, se encontram disponíveis gratuitamente em bases públicas, as etapas de processamento e análise são realizadas de forma rápida e eficiente. Tal característica confere ao geoprocessamento um papel estratégico na gestão territorial e no planejamento urbano sustentável, permitindo que gestores públicos compreendam a dinâmica de crescimento das cidades com precisão e agilidade, subsidiando políticas ambientais e de uso do solo. A integração entre geoprocessamento e Inteligência Artificial mostrou-se uma ferramenta indispensável para monitorar transformações espaciais, fornecer diagnósticos ambientais em tempo real e orientar tomadas de decisão fundamentadas em evidências.

Palabras clave: Geoprocementamiento. Inteligencia Artificial. Supresión Vegetal. Expansión Urbana. Análisis Temporal.



1 INTRODUCTION

The advancement of geoprocessing technologies has revolutionized the ways of analyzing the territory, making it possible to understand the spatio-temporal dynamics of natural and anthropic environments with high precision. According to Florenzano (2011), geoprocessing is a set of techniques that integrates spatial data and descriptive attributes, allowing the mapping and modeling of geographic phenomena. These technologies, associated with satellite images and aerial photographs, provide essential data to assess urban growth, habitat fragmentation, and the suppression of vegetation areas, phenomena intensified in recent decades by the rapid process of urbanization in Brazil (IBGE, 2020).

The use of historical aerial images is a valuable tool for understanding the evolution of land occupation. According to Novak (1996), aerial photogrammetry allows the generation of cartographic products from photographs obtained by aircraft, providing metric and interpretative data that make it possible to reconstruct past landscapes. These images, when georeferenced, offer time series that show gradual changes in the territory, such as the urban advance over permanent preservation areas and riparian zones. According to Jensen (2006), multitemporal analysis is fundamental for environmental planning, as it allows the identification of patterns of vegetation suppression, expansion of the urban fabric and degradation of ecosystems over time.

In addition to aerial photographs, the use of satellite images has gained prominence for its ability to monitor continuously on a large scale. Richards and Jia (2012) state that orbital remote sensing has become one of the main tools for detecting environmental changes, allowing the estimation of deforested areas, land use dynamics, and the expansion of cities with high accuracy.

In this scenario, the integration between geoprocessing, historical images and new computational technologies has become an emerging trend in the scientific field. Artificial Intelligence (AI), according to Russell and Norvig (2020), represents one of the greatest innovations today due to its ability to interpret large volumes of data, recognize patterns, and provide predictive analysis. The use of AI applied to geospatial imagery has stood out in the automatic classification of land use and land cover, detection of deforestation and identification of irregular occupations, this work proposes an innovative approach by using AI not only as a classification tool, but as an interpretative instrument of geospatial data obtained through digitized historical aerial images.

The use of aerial photographs obtained in 1960, 1970, 2003 and 2025 allowed us to analyze the evolution of the urban landscape of the city of Assis (SP), a representative region of medium-sized cities in the interior of São Paulo. These cities, as observed by Santos and Silveira (2001), have played a strategic role in the process of industrial deconcentration and expansion of the national urban fabric, often associated with accelerated and poorly planned urbanization processes. The interpretation of the images revealed clear trends of advance of the urban fabric over natural areas, especially in the region of Ribeirão da Fortuna, evidencing the suppression of native vegetation and the intensification of soil impermeabilization.

Aerial photogrammetry, when integrated with digital image processing and Geographic Information Systems (GIS) tools, allows the precise delimitation of vegetation areas and buildings, enabling the quantification of vegetation suppression over time (Burrough & McDonnell, 2015). In this sense, multitemporal analysis becomes fundamental to evaluate the environmental impacts resulting from urban growth and to provide subsidies for public policies aimed at territorial planning and the conservation of natural resources.

The differential of this study lies in the application of Artificial Intelligence for automatic interpretation of data organized in tables, generated from the digitization of georeferenced aerial images. While previous studies are limited to human analysis of data, this work proposes an innovative approach, using AI as a spatial diagnostic tool, capable of analyzing patterns of urban expansion and vegetation suppression based on historical series. According to Goodfellow, Bengio and Courville (2016), AI models have a high capacity for generalization and learning, making them able to detect subtle changes in images over time, contributing to the understanding of territorial behavior and future land use projections.

Thus, this study seeks to answer the following central question: how can the temporal analysis of historical images associated with automated interpretation by artificial intelligence contribute to the understanding of the processes of vegetation suppression and urban expansion? The research presents itself as a significant contribution to the field of geoprocessing applied to territorial planning and environmental management, especially in a context of growing demand for digital technologies that assist in evidence-based decision-making.

In addition to technical accuracy, it is noteworthy that the use of georeferenced historical images and geoprocessing tools is highly cost-effective, because, after the initial data is obtained, the processing, digitization and analysis steps can be carried out quickly, with accessible or free software, which makes this type of study feasible for municipalities,

researchers and public institutions. The agility in spatial interpretation allows the evaluation of the development of cities in short intervals of time, contributing to sustainable urban planning and efficient environmental management (IBGE, 2020).

In this context, the objective of this work is to develop a study of the evolution of land occupation in a specific region of the municipality of Assis (SP), using geoprocessing and historical aerial images as tools to analyze urban expansion and the suppression of vegetation areas, also considering the advantages of low cost, high processing agility and practical applicability of these technologies in territorial planning and city management.

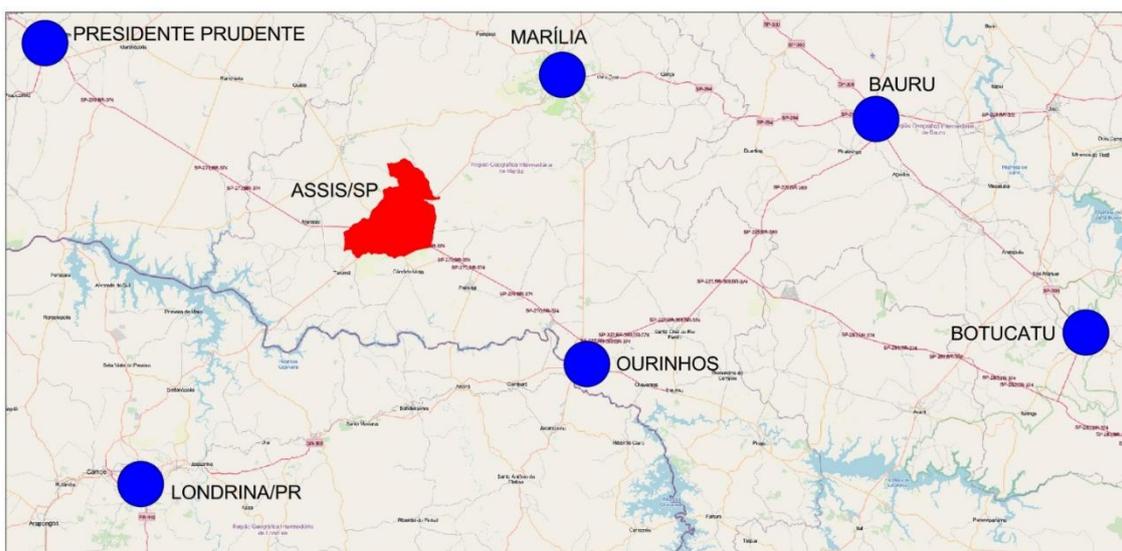
2 MATERIALS AND METHODS

2.1 FIELD OF STUDY

The study was carried out in a region located in the municipality of Assis, State of São Paulo, covering urban and permanent preservation areas located in the surroundings of Ribeirão da Fortuna. The area was selected because it has a history of urban expansion and vegetation suppression, being representative of the process of territorial transformation that has occurred over the last decades in medium-sized municipalities in the interior of São Paulo.

Figure 1

Location of the city of Assis in relation to the main cities in the region



To carry out this work, historical aerial photographs from the 1960s and 1970s were used, obtained through public collections of aerial photogrammetry, high-resolution aerial

image from the years 2003 and 2025, made available by digital geoprocessing platforms, as well as for the georeferencing and vector digitization of the images, the AutoCad 2025 software was used.

ChatGPT Artificial Intelligence (OpenAI – GPT-5): applied for automated interpretation and analysis of quantified data, identification of patterns of vegetation suppression and urban expansion.

Electronic spreadsheet (Excel): used for data organization and calculation of percentages and generation of tables.

The historical aerial images were imported into the AutoCAD 2025 software, where they were georeferenced from spatial reference points, ensuring the correct overlap between the different years analyzed. The UTM coordinate system, spindle 22S, Datum SIRGAS 2000, was adopted, in accordance with the Brazilian cartographic guidelines.

After georeferencing, the features were manually vectorized, classifying them into two categories: urban area: represented by houses, buildings, paved roads and allotments and vegetated area: encompassing native forests, permanent preservation areas (APP), pastures and forests.

Each class was delimited by vector polygons, allowing the quantification of the areas in hectares. With the polygons scanned, AutoCAD automatically generated the area values (in m²), which were converted into hectares (1 ha = 10,000 m²). The data were organized in an electronic spreadsheet to compose the table and calculate the percentage of urban occupation and vegetation suppression in each period analyzed.

Data analysis was carried out based on the comparison of the four historical periods: 1960, 1970, 2003 and 2025. For each year, the following were calculated:

- Total area analyzed
- Urban area
- Vegetated area
- Percentage of urban sprawl
- Percentage of suppression of vegetation cover

This comparison allowed us to identify the pace of urban growth and the reduction of vegetation over time.

The quantified data were entered into an Artificial Intelligence environment (ChatGPT – OpenAI), in which AI was used to automatically interpret land occupation trends, identify spatial patterns of vegetation suppression, point out potential environmental impacts resulting

from urban growth, generate projections and qualitative inferences about the observed results. This stage represents the technological innovation of this study, demonstrating the potential of AI as a tool for environmental interpretation and support for sustainable urban planning.

3 RESULTS AND DISCUSSION

The work began with the insertion of the image (Figure 2) in the ChatGPT Artificial Intelligence, requesting that the tool perform a visual interpretation of the studied area. The following are the main information automatically identified by the AI.

"This image is an aerial (satellite) view of an urban and peri-urban area of the city of Assis/SP, clearly showing natural and urban elements in interaction processes".

Here are the main visible elements: As natural elements, it indicated the following information based on Figure 2.

There is in figure 2 the Ribeirão da Fortuna that is identified with the name in the image and is an important watercourse that crosses the area. A stretch of riparian forest and dense vegetation can also be seen: located mainly around the stream, indicating a remnant of preserved vegetation or a permanent protection area.

Rural areas and pastures on the left of the image, with a typical pattern of agricultural lots or pasture areas, some urban elements visible especially in the central and right part of the image, with a high density of housing, there is also a recent housing complex in the upper left part, with organized blocks and straight streets, indicating planned and more recent occupation. Consolidated urban fabric on the right, with smaller blocks, paved streets and high density.

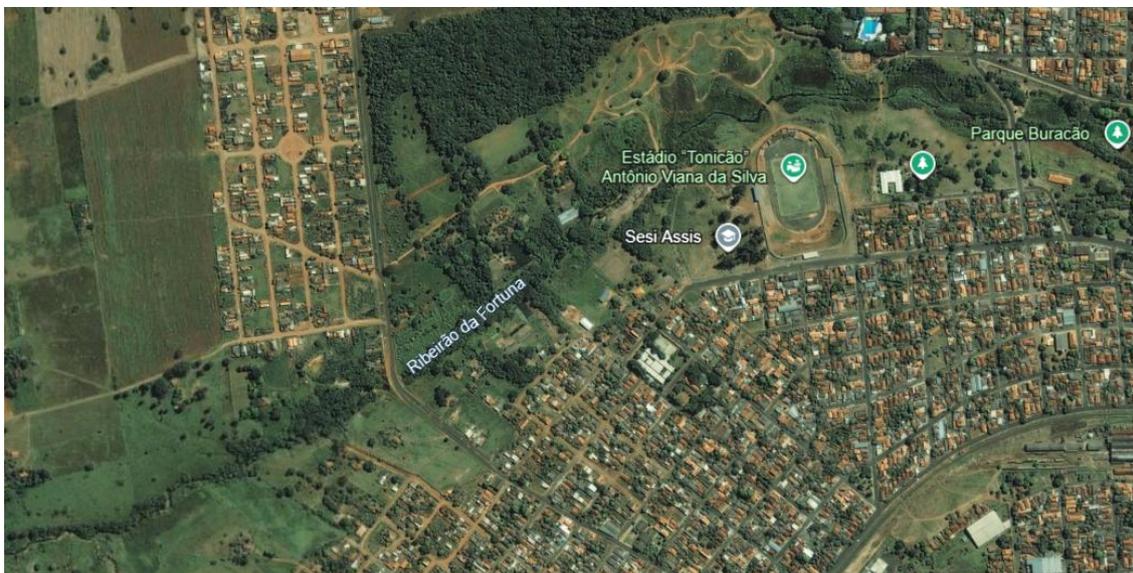
Also analyzing the image, ChatGPT identified important public equipment such as the "Tonicão" Antônio Viana da Silva Stadium: a large sports structure.

The Buracão Park is a green area for leisure and public recreation in the northeastern portion of the city.

The Fortuna stream acts as an ecological corridor and natural divider between the urban and rural sectors, there are also indications of urban expansion towards areas of vegetation and proximity to water bodies, which can be analyzed from the point of view of environmental impact or urban planning.

Figure 2

Aerial image of the study site in 2003



Then, Figure 3 was inserted into ChatGPT, corresponding to the 2025 aerial image, asking the AI for a direct comparison with the previous image to identify the changes that occurred over time.

Figure 3

Aerial image of the study site in the year 2025



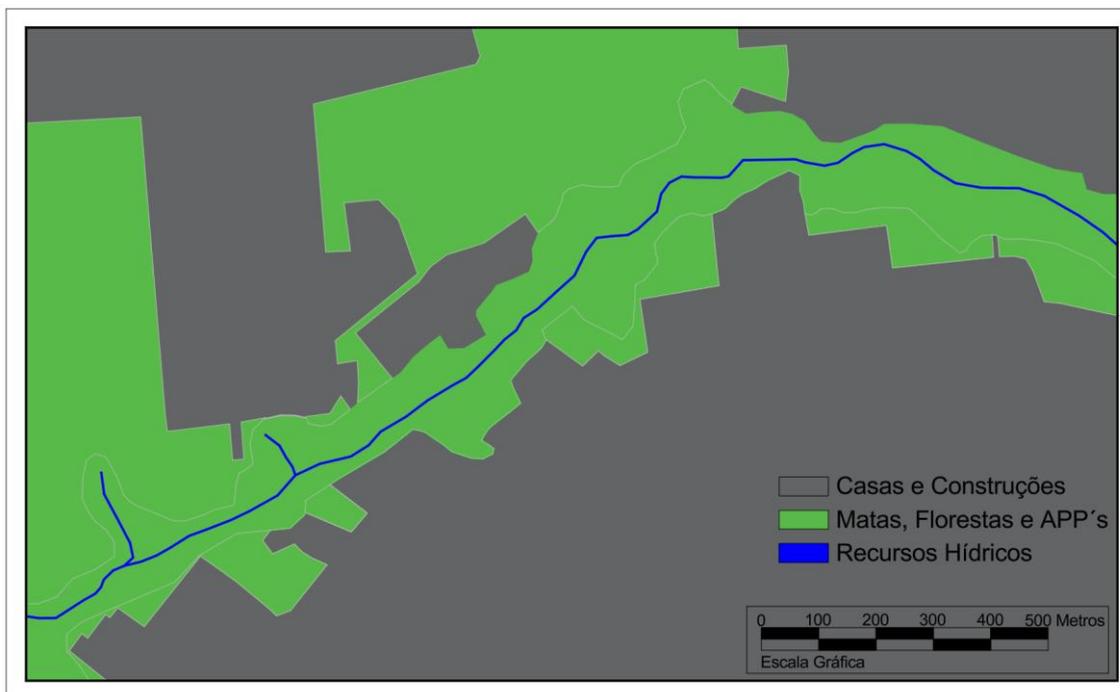
Comparing aerial images from the years 2003 and 2025, Artificial Intelligence identified significant changes in the urban landscape of the area studied. A significant increase in urban occupation was observed, especially in the vicinity of Ribeirão da Fortuna, where there was a densification of housing and expansion of the built network towards the west and south.

At the same time, there was a reduction in green areas and natural vegetation, with a decrease in riparian forest and replacement of old vegetated spaces by streets and buildings. Urban infrastructure has become more consolidated, with new allotments and paved roads, resulting in greater integration between neighborhoods and a less clear transition between the urban and rural perimeter.

These transformations indicate a continuous process of urban expansion and increased pressure on environmentally sensitive areas, typical characteristics of the accelerated growth of medium-sized cities in the interior of São Paulo.

Figure 4

Digitization of the areas under the 2025 aerial image



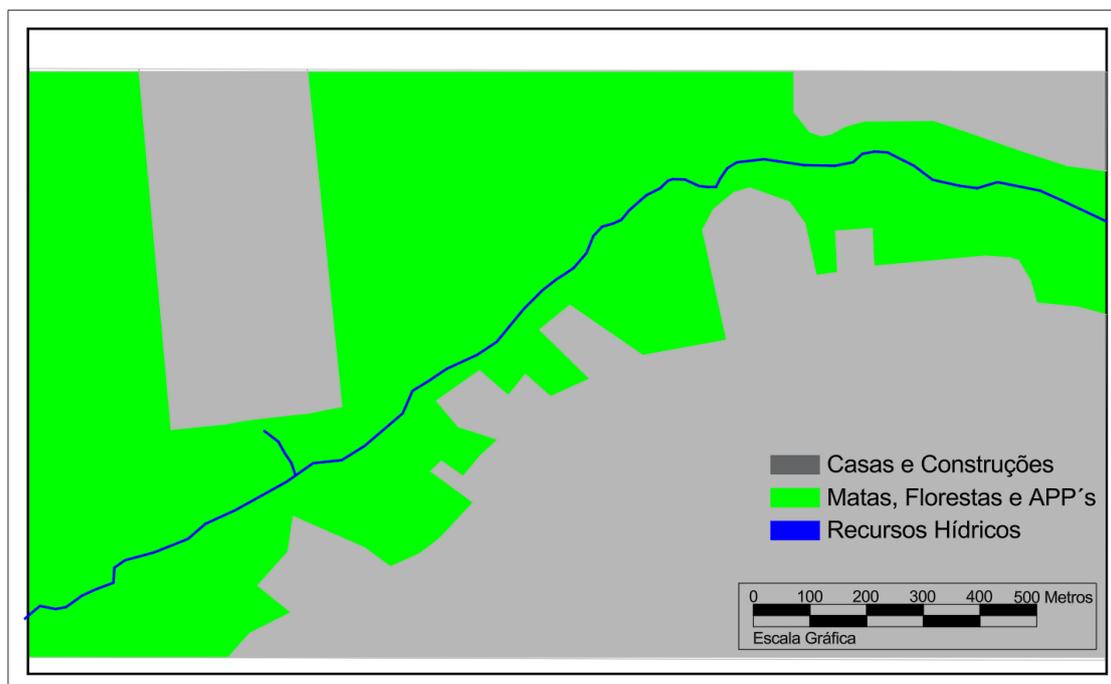
Based on the data presented, the aerial images referring to the years 1960, 1970, 2003 and 2025 were submitted to vector digitization. From this procedure, quantitative information was obtained that supports the analysis of the spatial evolution of the study area and supports the results presented below.

The vector digitization of the image for the year 2025 (Figure 4), carried out in the AutoCAD 2025 software, resulted in the quantification of 140.41 hectares occupied by urbanized areas (houses and buildings) and 78.18 hectares corresponding to vegetated areas, totaling the analyzed area.

Similarly, the digitization of the 2003 aerial image (Figure 2) allowed the distinction between vegetation areas (pastures, forests, forests and PPAs) and built-up areas, enabling the temporal comparison of land occupation and the identification of trends in urban expansion and vegetation suppression.

Figure 5

Digitization of the 2003 aerial image



The digitization of the aerial image for the year 2003 resulted in the quantification of a total of 199.14 hectares, of which 92.61 hectares corresponded to urbanized areas (houses and buildings) and 106.53 hectares were occupied by vegetation, including forests, forests and Permanent Preservation Areas (APPs).

Figure 6

Aerial photo of the city of Assisi in 1960

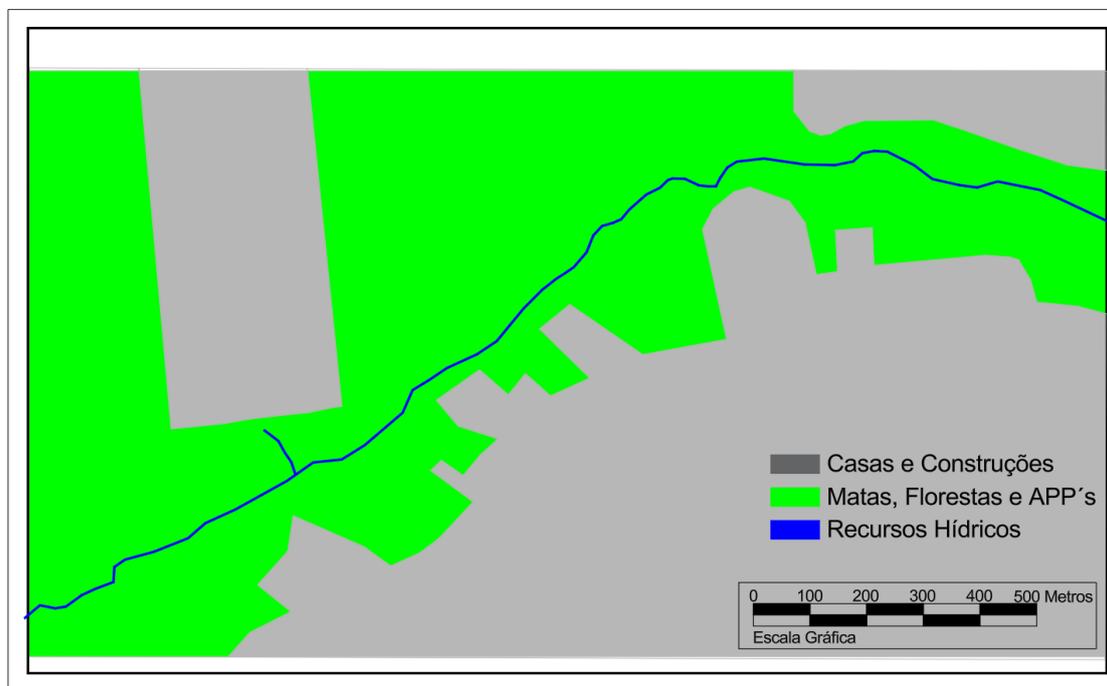
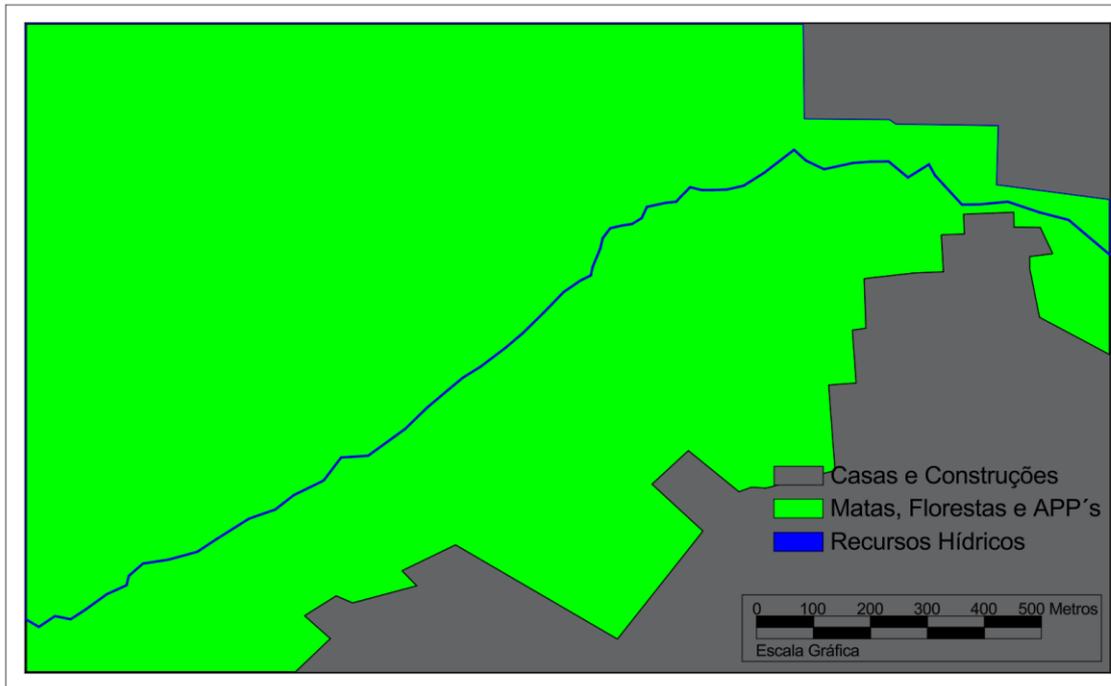


Figure 6 shows the aerial photograph of the city of Assis for the year 1960, obtained by means of aerial survey with aerial photogrammetry techniques. After georeferencing, the image was positioned in its original location in the coordinate system, allowing the delimitation and calculation of urbanized areas and areas of vegetation existing in that period. It is a valuable historical record, with more than six decades, which demonstrates the importance of the integration between historical images and geoprocessing for understanding the evolution of land occupation.

Figure 7

Digitization of the Aerial Image of the year 1960



The vector digitization of the aerial image from 1960 (Figure 7) resulted in the quantification of 154.52 hectares of vegetation cover, encompassing forests, forests and Permanent Preservation Areas (PPAs), and 64.08 hectares occupied by urban constructions, totaling 218.60 hectares analyzed in that period.

Figure 8 shows the aerial image for the year 1970, corresponding to the same study area. This image was submitted to the digitization process to obtain land cover data and compare the spatial evolution between the different periods analyzed.

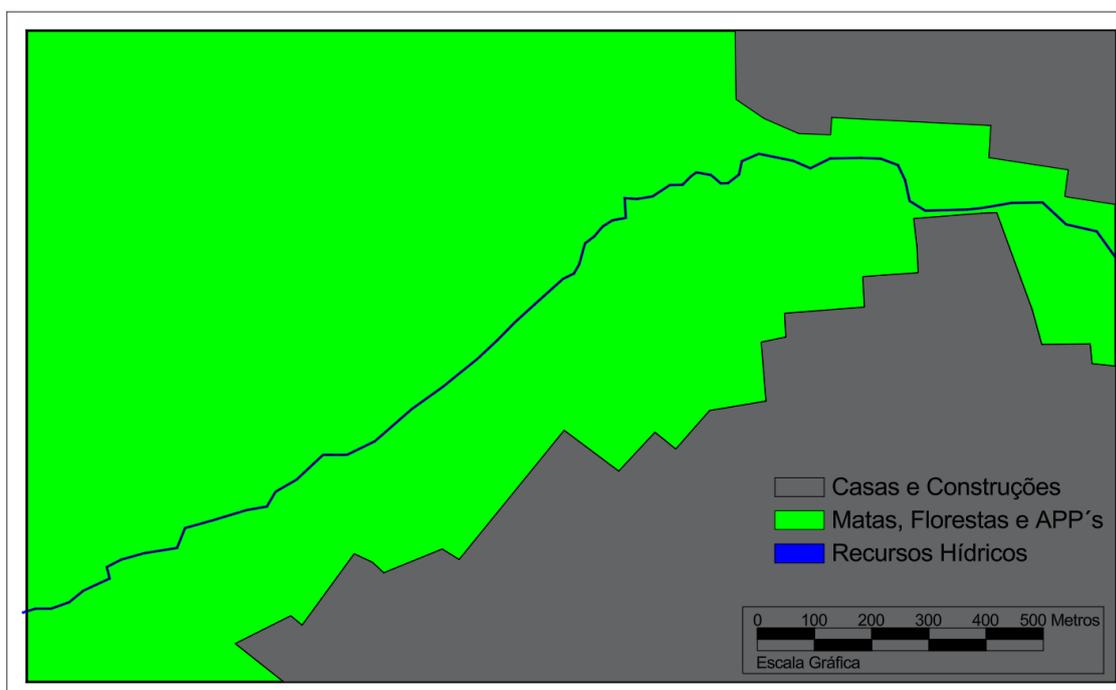
Figure 8

Aerial photo of the city of Assisi in 1970



Figure 9

Digitized photo from the year 1970





The digitization of the aerial image from 1970 allowed the delimitation of the areas of urban occupation and vegetation cover. 83.06 hectares of built areas (houses and buildings) and 135.54 hectares of vegetation were identified, including pastures, forests, forests and Permanent Preservation Areas (PPAs), totaling 218.60 hectares analyzed.

From the data obtained for the four historical periods (1960, 1970, 2003 and 2025), it was possible to quantify the evolution of urban expansion and the suppression of vegetation in the study area. This multitemporal analysis evidenced the changes in land use and land cover over the decades, allowing the construction of the following table, which summarizes the results obtained.

Table 1

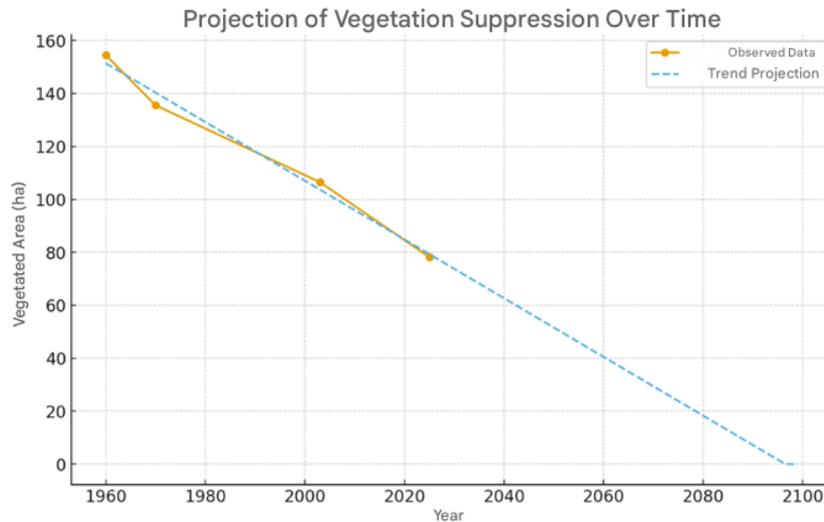
Evolution of land occupation in the municipality of Assis (SP) based on historical aerial images

Year of the image	Total area analysed (ha)	Urban area (houses/buildings)	Vegetated area (forests, pastures, APPs)	Urban percentage (%)	Percentage vegetated (%)
1960	218,6	64,08	154,52	29,30%	70,70%
1970	218,6	83,06	135,54	38,00%	62,00%
2003	199,14	92,61	106,53	46,50%	53,50%
2025	140,41*	62,23*	78,18*	44,30%	55,70%

With reference to the data above, Artificial Intelligence through ChatGPT made its quantitative analysis below:

Figure 10

Projection of Vegetation Suppression Over Time

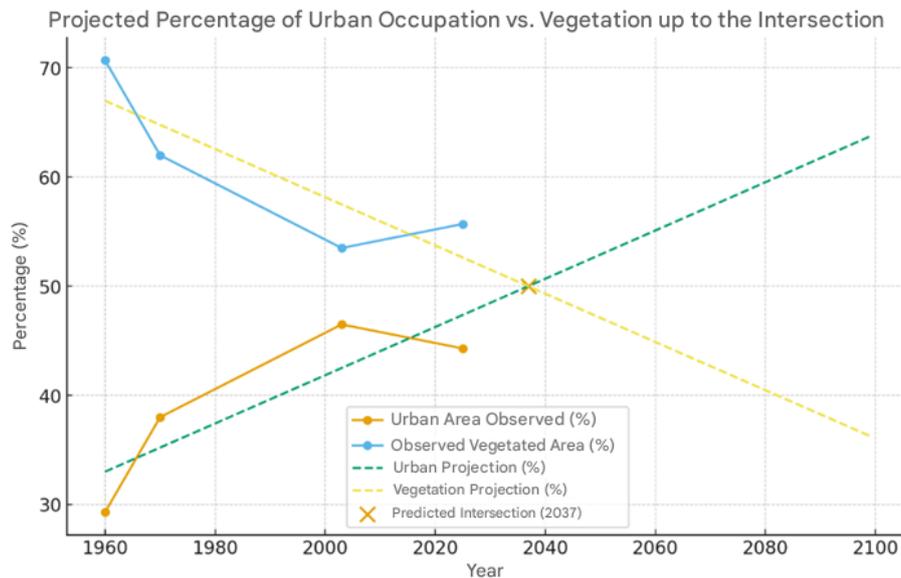


The generated graph represents the projection of vegetation suppression over time, based on real data from the years 1960, 1970, 2003 and 2025. The linear trend analysis indicates that the vegetation cover of the studied area shows a continuous pattern of reduction over the last decades. If the observed dynamics remain unchanged and no environmental restoration or preservation measures are implemented, it is estimated that the vegetation area may reach values close to zero between the years 2090 and 2100, implying the almost total disappearance of the remaining green areas. This result shows a critical scenario of environmental collapse, especially in areas close to rivers and springs, such as Ribeirão da Fortuna, highlighting the urgency of public policies for conservation and territorial planning.

Another relevant figure created by Artificial Intelligence was graph 2, which simulates the crossing of data, that is, when the percentage of buildings and houses becomes equal to or greater than the percentage value of vegetation areas in this same place.

Figure 11

Percentage Projection of Urban Occupation x Vegetation until the crossing of percentage values



The percentage analysis demonstrates a linear trend of convergence between the land use classes. Based on historical data and statistical projection, it is observed that urban occupation should reach 50% of the total area in approximately 2037, when it will equal the vegetation cover. From this point on, if environmental preservation and recovery policies are not implemented, the built areas will predominate over the vegetation, indicating a warning scenario for the environmental and urban sustainability of the region studied.

4 CONCLUSION

The temporal analysis of aerial images from the years 1960, 1970, 2003 and 2025 showed a significant advance in urban occupation over natural areas in the municipality of Assis (SP), resulting in significant vegetation suppression over the last decades. The integration between geoprocessing and Artificial Intelligence allowed us to interpret this dynamic, identifying urban growth trends that point to the intersection of the percentages of built and vegetated area around 2037, suggesting possible urban predominance in the near future.

One of the main differentials of this work was the use of low-cost technologies and high operational efficiency. After obtaining the aerial images, many of them available for free in public databases, the entire process of georeferencing, digitization, quantification and

automated interpretation occurred quickly and with minimal financial investment. The application of AI has accelerated the analytical steps, allowing the immediate generation of environmental diagnoses and future projections with scientific reliability.

Thus, it is concluded that the methodology adopted proves the impact of urban expansion on the reduction of vegetated areas, in addition to demonstrating the potential of digital tools as strategic allies in sustainable territorial planning. The study shows that it is possible to produce high-quality technical knowledge at low cost, speed of processing and practical applicability, making this approach extremely viable for public managers, researchers and institutions looking for efficient solutions for environmental and urban monitoring.

REFERENCES

- Burrough, P. A., & McDonnell, R. A. (2015). Principles of geographical information systems (2nd ed.). Oxford University Press.
- Florenzano, T. G. (2011). Iniciação em sensoriamento remoto. Oficina de Textos.
- Goodfellow, I., Bengio, Y., & Courville, A. (2016). Deep learning. MIT Press.
- IBGE – Instituto Brasileiro de Geografia e Estatística. (2020). Censo demográfico 2020: População e expansão urbana no Brasil. IBGE.
- Jensen, J. R. (2006). Remote sensing of the environment: An earth resource perspective (2nd ed.). Pearson Prentice Hall.
- Novak, K. (Ed.). (1996). Digital photogrammetry: An addendum to the manual of photogrammetry. American Society for Photogrammetry and Remote Sensing.
- Richards, J. A., & Jia, X. (2012). Remote sensing digital image analysis: An introduction (5th ed.). Springer.
- Rodrigues, R. J., Palmieri, D. A., Souza, E. B., & Oliveira, O. P. S. (2025). Uso de softwares para determinação de microbacias e posterior cálculo de estimativa de vazão máxima. *Brazilian Journal of Development*, 11(8). <https://doi.org/10.34117/bjdv11n8-005>
- Russell, S. J., & Norvig, P. (2020). Artificial intelligence: A modern approach (4th ed.). Pearson.
- Santos, M., & Silveira, M. L. (2001). O Brasil: Território e sociedade no início do século XXI (1st ed.). Editora Record.